POWER PLANT ENGINEERING

Established Over 33 Years

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It's a Pipe!

THAT'S WHAT EVERYBODY said about the job. The welders said so in spite of the fact that there was a 12-in. steam line 1700 ft. long to be welded, a 6-in. condensate return line and a compressed air line, all carried on the same supporting structure. It was a pipe for the welders because the lines themselves and the entire supporting structure were designed especially for electric arc welding, hence the work went along smoothly and rapidly and when they had finished it and tested it under pressure only two small pin leaks were found in the entire job. The engineers of the Westinghouse Electric & Mfg. Co. thought it was a pipe, too, because the job resulted in a uniform, flexible installation on a supporting structure using the minimum of steel and erected at extremely low cost. The line was erected to supply steam to the company's new manufacturing buildings at Trafford, Pa.

For pipe line work of this kind and for many other types of power plant work, welding has made a permanent place for itself among the methods of fabrication and repair of equipment. Some of these methods are shown in detail on page 1013 of this issue.

It's a pipe, also, to get the best results from the thermal standpoint on a steam line like this if it is properly designed as a steam carrier, with proper provision for draining condensation from it so that pressure drop will be moderate and steam delivered free of excessive moisture. To do this, definite principles govern the design of the pipe itself and the location of drain piping and traps to remove the condensate. These principles are discussed in detail on page 1006 of this issue by J. W. Brassington.

Power Plant Renders V

At new plant of American Bemberg Corp., Elizabethton, Tenn., demands for electric power, process water, air conditioning, compressed air and steam lead to interesting and unusual power plant layout. Extraction and non-condensing turbines, driving generators, compressors and pumps, furnish 5-lb. steam for heating process water.

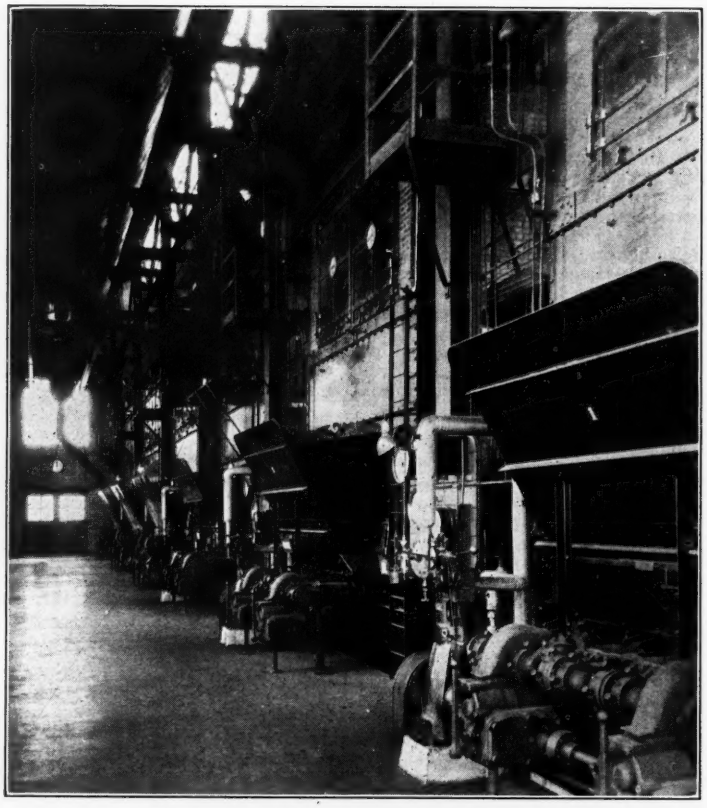


Fig. 1. Boiler Room supplies steam to turbines, compressors and mill.

PROCESSES used at the plant of the American Bemberg Corp., Elizabethton, Tenn., for making rayon from cotton linters, require all the varied services that can be rendered by the modern power plant engineer and the air conditioning expert. This article will discuss the unusual characteristics of the power plant that serves this great industry.

Various temperatures and humidities must be maintained continuously, summer and winter, at various steps in the process. Refrigeration is necessary at some points. Water at various uniform temperatures ranging from about 50 to about 200 deg. must be available in large quantities. Steam and compressed air for process work must be supplied, together with electric power for lighting and for driving machinery.

Basis of Design

In designing a power plant to render these services to a rayon mill, reliability of service is one of the principal factors influencing the design and every effort was made to secure it at the Bemberg plant. A shut-down of any part of such a mill means shutting down many of the preceding and following operations, so that the cost of a shut-down must be calculated on the work necessary to get the entire plant back to where it was just before the shut-down.

Economy was also an important factor, of course, in the design of the Bemberg plant. The demand for large quantities of hot water permitted the use of non-condensing and extraction turbines, making electric power as a by-product, while the large amount of spinning water that had to be pumped made it desirable to use this water in the condenser of an extraction turbine before the water went to the mills. Owing to the comparatively steady demand for steam during 6 days a week, stokers were selected for firing the boilers. On account of the low-priced coal that was available and the large amount of heat returned to the boilers in the form of condensate, it was felt that economizers and air preheaters were not justified. These factors, together with the necessity for the greatest reliability, influenced the design of a boiler plant for simplicity, ruggedness and convenience of operation.

Before considering in detail the services rendered by the power plant, a brief description of the outstanding features of the equipment will aid in understanding its operation. More complete data on the various items are given in the list of equipment.

The original design for the manufacturing plant

s Variety of Services *to a large* RAYON MILL

called for its erection in several units, therefore, to serve the first unit, the original power plant installation consisted of three 404-hp. stoker-fired boilers, two 750-kw. non-condensing turbine generators, two 1000-c.f.m. air compressors, a refrigerating compressor and the necessary coal-handling system and auxiliaries. The second manufacturing unit has now been completed and to the power plant have been added three 639-hp. stoker-fired boilers, a 1500-kw. mixed-pressure extraction turbine generator, two centrifugal refrigerating machines and the necessary auxiliaries, all as provided in the original design. Thus the plant at present appears as in the illustrations.

In the turbine room, as shown in Fig. 2, three turbine generator sets furnish power, two of them exhausting at 5 lb. pressure to an exhaust header, the third, a 1500-kw. unit, exhausting part of its steam to a condenser, with steam either extracted from or admitted to its low-pressure stages at 5 lb. pressure. These turbines take steam at a throttle pressure of 250-lb. and a superheat of 135 deg. They are all 3600-r.p.m. machines, making 3-phase, 60-cycle power at 480 v.

Exciters mounted on the shafts of the 750-kw. units furnish excitation for them. The 1500-kw. unit, however, is excited from a 30-kw., 125-v. motor-generator set, a duplicate set being installed for standby service. An exciter bus on the switchboard can be fed from this separate exciter to supply all generating units if necessary.

Electrical Connections

Electric power, generated at 480 v., goes to the mill for power and lighting; some of it, however, goes from the generators through the main oil circuit breakers on the switchboard to a bank of three single-phase, 1000-kv-a. transformers at one end of the station. These are located at ground level in a concrete transformer vault. They transform the voltage from 480 to 2300 v. for transmission to a filter plant on the bank of the Wautanga River, about ¼ mi. from the plant. At this filter plant, all water for the plant is filtered and pumped to

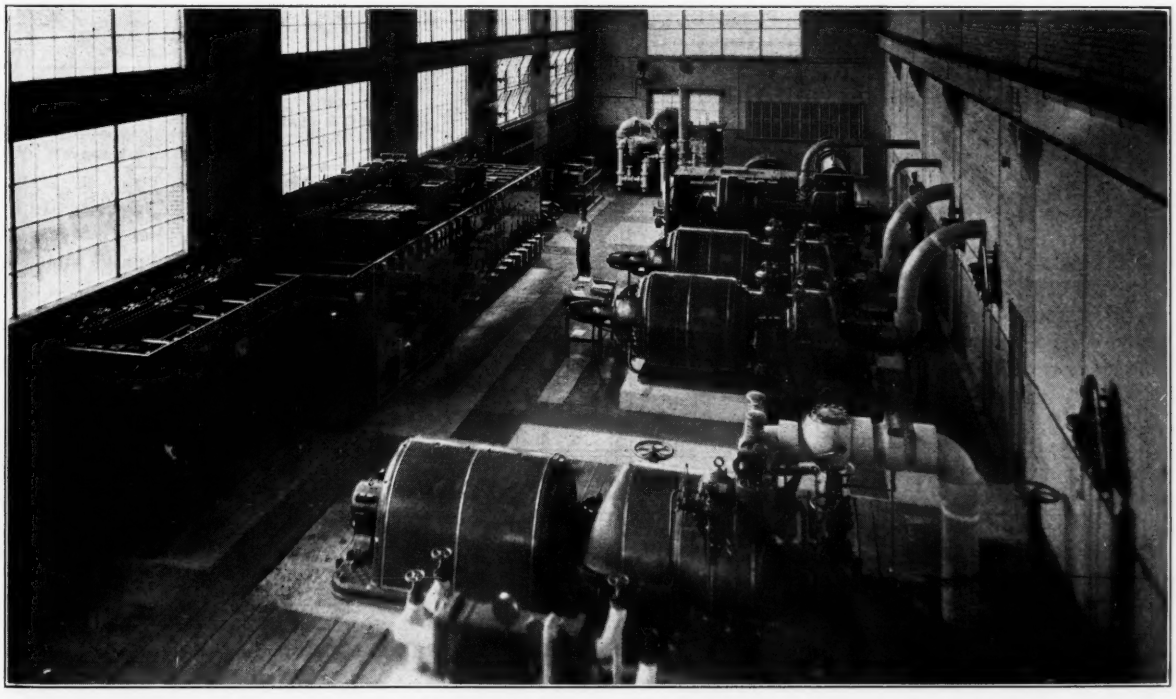


FIG. 2. TURBINE ROOM CONTAINS THREE TURBINE-GENERATORS, TWO AIR COMPRESSORS AND TWO CENTRIFUGAL REFRIGERATING COMPRESSORS

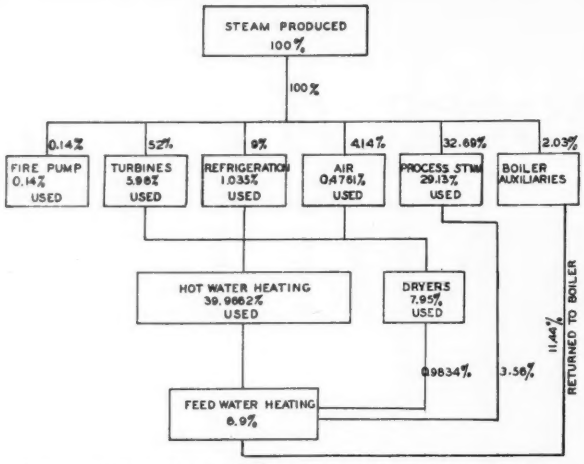


FIG. 3. HEAT BALANCE DIAGRAM OF POWER PLANT AND MILL

the power plant and mill, as will be explained later. Voltage at the filter plant is again stepped down to 480 v. by a bank of three 333-kv-a. transformers. The 480-v. motors driving these filter plant pumps do not draw as much as the full capacity of the main 480/2300-v. transformers but these transformers have another important function. Through automatic switching devices they tie in with a transmission line running about ½ mi. to the neighboring plant of the American Glanzstoff Corp.

Thus each of these power plants has an outside source of power for use in case of emergencies that might require shutting down any of the generating units. In this way, the lighting circuits, power plant auxiliaries and essential production machinery can be kept in continuous operation. For emergency lighting circuits, a 50-kv-a. transformer is installed to step the voltage down from 2300 to 110 v. Emergency power at 440 v. is obtained from the 2300-v. line through a bank of three 75-kv-a. transformers. An automatic throw-over device is arranged so that in case of trouble, the normal service is cut out and the emergency transformers, taking power direct from the 2300-v. tie with the Glanzstoff plant, are cut in.

In the turbine room, two 1000-c.f.m. compressors are installed to supply compressed air at 100 lb. pressure to the factory. One of these is steam-driven; the other is driven by a direct-connected synchronous motor, pro-

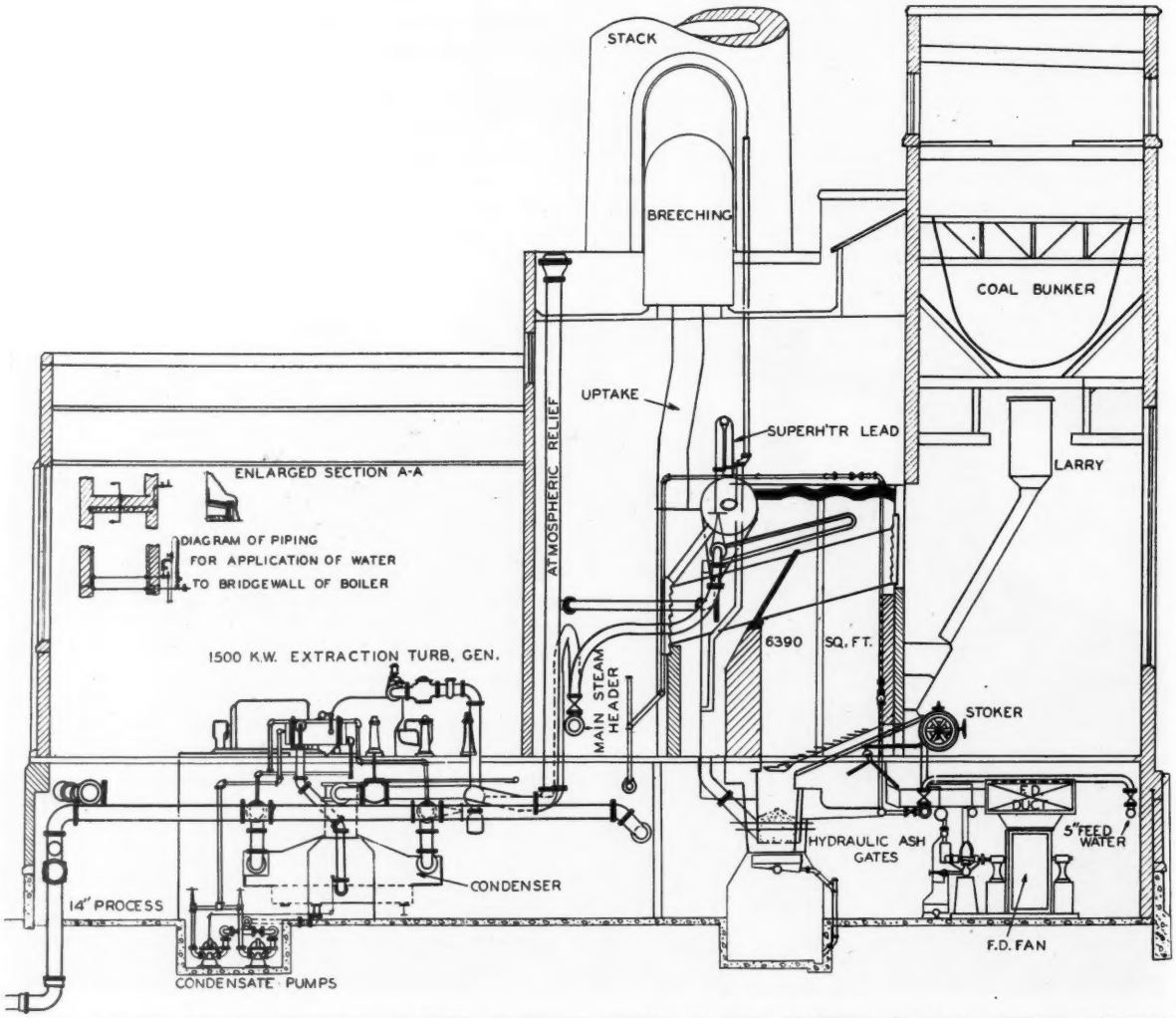


FIG. 4. CROSS-SECTION THROUGH NEWER PART OF POWER PLANT, SHOWING 1500-KW. MIXED-PRESSURE EXTRACTION UNIT AND 639-HP. BOILERS

viding the proper low speed for direct connection and at the same time affording power factor correction.

Two centrifugal refrigerating compressors, mounted on the turbine room floor furnish refrigeration to cool water that is pumped to the factory buildings to be used in air conditioning and refrigerating equipment. One of these units has a refrigerating capacity of 175 t., the other of 210 t. per 24 hr. Both are driven at variable speed (3000-3800 r.p.m.) by 300-hp. steam turbines. A surface condenser with suitable auxiliaries is provided so that either or both of these turbines can be operated full condensing, if required by the heat balance conditions of the plant. Otherwise, either or both of them can exhaust at 5 lb. back pressure to the exhaust header.

ing devices used in the bridge walls just above the dump plates to prevent clinker formation at this point. In these cooling devices, shown in section in Fig. 4, horizontal water pipes leading through the bridge walls discharge water through nozzles near the face of the walls so that it will trickle down over the brickwork to prevent slagging and erosion. In addition, the furnaces of the three 639-hp. boilers have rows of carborundum brick along the clinker line above the stokers.

Engines and Turbines Drive Multiple Retort Stokers

Stokers of the multiple-retort underfeed type fire these furnaces with coal of about 13,000 B.t.u. per lb.; settings and stokers are designed to operate the boilers

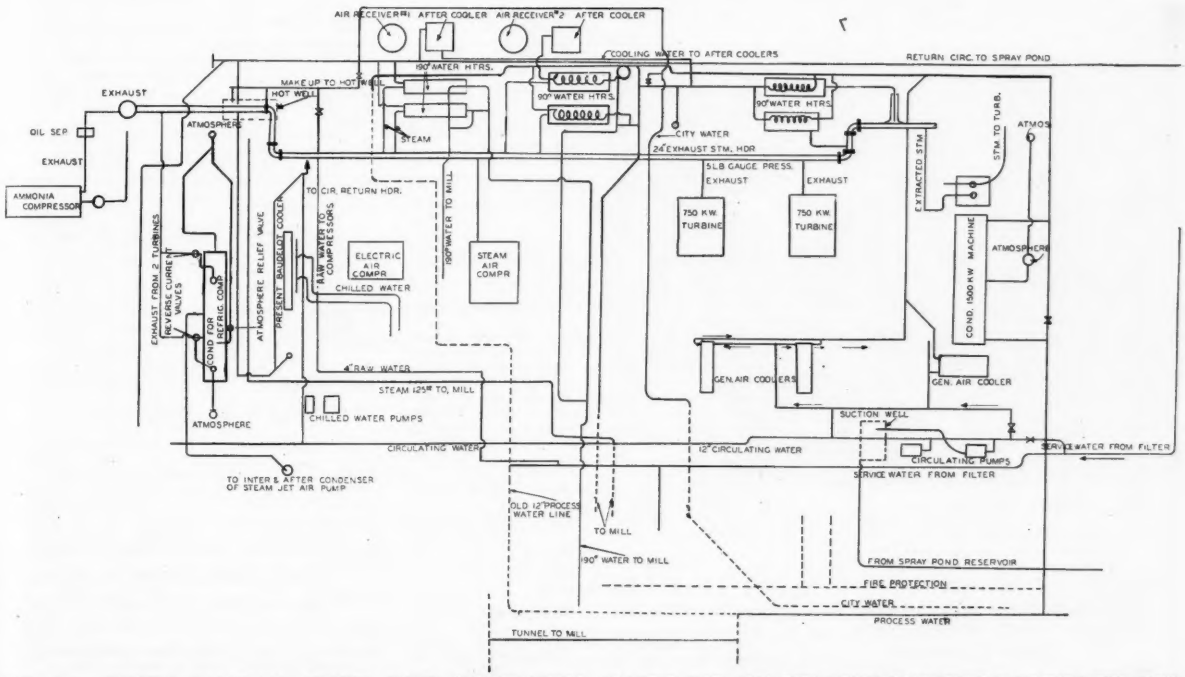


FIG. 5. PIPING DIAGRAM SHOWS HOW CIRCULATING WATER FOR 1500-KW. UNIT CONDENSER IS HEATED FOR PROCESS WATER AND HOW OTHER UNITS TAKE CIRCULATING WATER FROM SPRAY POND SYSTEM

For cooling process water to the plant and for making ice, a 75-t. steam-driven ammonia compressor, with ammonia condenser, cooling tank and circulating pumps is installed in the turbine-room basement.

Here also we find the various circulating, service and boiler feed pumps, the process water heaters, exhaust header and an extremely important system of water piping that will be discussed later.

Boiler Room

Steam for the above equipment is generated in the boiler room shown in Fig. 1 and in cross-section in Fig. 4. Here six stoker-fired boilers, three of 404-hp. capacity and three of 639-hp. capacity, make steam at 250-lb. header pressure, 135 deg. superheat. These boilers are of the straight-tube, cross-drum type with convection superheaters, the general arrangement of the settings being as shown in Fig. 4.

Furnace walls are of standard refractory construction without water or air cooling except for water cool-

continuously at about 200 per cent of rating, equivalent to a steam production of about 24,000 lb. an hour and 38,000 lb. an hour for smaller and larger boilers respectively. For short peaks they are designed to operate at about 300 per cent of rating. Individual steam engines drive the three stokers of the 404-hp. boilers; small steam turbines with gears, all built as an integral part of the mechanism, drive the stokers of the 639-hp. boilers.

Three forced draft fans, two motor-driven and one steam turbine-driven, supply combustion air to these stokers. These fans feed into a common air duct in the basement from which air is taken to the stoker air chambers by ducts, the whole arrangement being dampered so that any or all of the fans can supply air to the main duct. Each fan has a capacity of 34,500 c.f.m. of air at 6-in. H_2O and 1162 r.p.m. One of the motor-driven fans is of the new variable-inlet, vane control type, driven by a constant speed motor, the variations in volume and pressure of air being controlled by changing the angle of the vanes at the fan

Principal Equipment in New Power Plant, American Bemberg Corp.

Boilers, Stokers and Accessories

BOILERS.....Springfield Boiler Co.
Number 6
Type .....Cross-drum ...horizontal water tube, straight tube
Size.....3 404 hp. each; 3 639 hp. each
Capacity, each .....
Continuous, 200 per cent rating, 24,000 and 38,000 lb. steam an hr.
Maximum, 300 per cent rating, 36,000 and 57,000 lb. steam an hr.
Steam pressure.....250 lb. gage
SUPERHEATERS.....Foster Wheeler Corp.
Heating surface..3 238 sq. ft.; 3 376 sq. ft.
Steam temperature....535 deg. F., 135 deg. superheat at 175 per cent rating
Number 6
Type .....Convection
STOKERS.....Riley Stoker Corp., ...Westinghouse Elec. & Mfg. Co.
Number.....6 (3 of each make)
Riley stokers .....
.....3 5 retort under 404 hp. boilers
Tuyeres 90
Grate area.....83.5 sq. ft.
Drive.....Troy Engine Co. 1-cyl. engines
Westinghouse stokers .....
.....3 7 retort under 639 hp. boilers
Drive....Westinghouse turbine gear drive
Tuyeres 168
Grate area.....135.5 sq. ft.
FURNACE CONSTRUCTION .....
Refractory with water-cooled bridge wall and carborundum brick along clinker line in 3 furnaces.
Furnace vol....3 752 cu. ft., 3 1356 cu. ft.
Ratio furnace volume to boiler h.s....
.....3 units, 0.186; 3 units, 0.21
Sq. ft. boiler h.s. per sq. ft. grate....
.....3 units 48; 3 units 47
WATER COLUMNS..Reliance Gauge Col. Co.
SOOT BLOWERS .....
.....Diamond Power Specialty Co.
FEEDWATER REGULATORS (Copes).....
.....Northern Equipment Co.
COMBUSTION CONTROL..Carrick Engrg. Co.
STEAM PRESSURE GAGES.....Ashcroft (Cons. Ashcroft Hancock Co., Inc.)
FLOW METERS...Republic Flow Meters Co.
.....Bailey Meter Co.
DRAFT GAGES.....Bailey Meter Co.
TEMPERATURE RECORDER (flue gas)....
American Schaeffer & Budenberg Corp.

Coal and Ash Handling Equipment

COAL HANDLING EQUIPMENT.....
.....Alvey-Ferguson Co.
Drag scraper, apron conveyor, crusher, belt conveyor, weigh larry, bunkers, capacity .....30 t. an hr.
ASH GATES.....Allen-Sherman-Hoff Co.
Number 6
Type..Hydraulically operated, water cooled Ash hoppers dump direct to trucks.

Draft Equipment

BREECHING.....Johnson City Foundry
CHIMNEY.....Rust Engineering Co.
Height, above grates.....180 ft.
Diameter..Bottom, 18 ft., 10 in.; top, 12 ft.
FORCED DRAFT FANS..B. F. Sturtevant Co.
Number....3 (2 motor-driven, 1 turbine)
Type.....1 variable inlet, 2 fixed inlet
Capacity..Each 34,500 c.f.m. at 6 in. H_2O
Drive .....
Variable inlet fan driven by Westinghouse 60-hp., 440-v. constant speed induction motor.
1 fixed inlet fan driven by 50-hp. Westinghouse wound-rotor variable speed a.c. motor.
1 fixed inlet fan driven by Sturtevant single-stage turbine.
FORCED DRAFT DUCTS.....Grinnell Co.
Type .....3 fans feed to common duct with dampers

Water Treating and Heating Equipment

FILTER.....Roberts Filter Mfg. Co.
Type .....Sand
Capacity.....8,600,000 gal. a day
SPRAY POND.....Grinnell Co.
Capacity .....6000 g.p.m.
HOT WATER HEATERS.....
..Griscom Russell Co., Cochrane Corp.
Use....Heating service and process water
Number 5
Type .....Closed
Capacity .....1—2000 g.p.m.; 2—1000 g.p.m.; 2—400 g.p.m.
HEATER TEMPERATURE CONTROLS.....
..Powers Regulator Co.,
..American Schaeffer & Budenberg Co.
FEEDWATER HEATER.....Cochrane Corp.
Number 1
Type.....Deaerating, metering, open
Capacity.....150,000 lb. per hr.

Pumps

BOILER FEED PUMPS.....
Goulds Pumps, Inc., Ingersoll-Rand Co.
Number.....3 (2 Goulds, 1 Cameron)
Type..... 6-stage centrifugal

	Goulds	Cameron
Capacity, each	200 g.p.m.	350 g.p.m.
Head	300 lb.	300 lb.

Drive .....
1 60-hp., 440-v., G.E. motor; West. 125-hp., 440-v. motor; 1 Sturtevant steam turbine.
CONDENSER WATER CIRCULATING PUMPS .....De Laval Steam Turbine Co.
Location.....At filter plant
Number 3
Capacity.....2000 g.p.m. each
Type .....Centrifugal
Head .....170 ft.
Drive....125-hp., 440-v. induction motors
SPRAY POND CIRCULATING PUMPS.....
.....2 De Laval Steam Turbine Co.
.....1 Warren Pump Co.
Type.....Centrifugal, 1 stage
Capacity...2—1500 g.p.m.; 1—3000 g.p.m.
Head .....55 ft.
Drive .....
De Lavals by 60-hp. G. E. motor; Warren by 40-hp. Westinghouse motor
HEATING SYSTEM RETURN PUMPS.....
.....Nash Engineering Co.
Number 8
BOOSTER PUMPS (Hotwell to F. W. Heater).....Nash Engineering Co.
Number 2
Capacity .....300 g.p.m.
Drive .....10-hp. G.E. motor
SUMP PUMPS.....Buffalo Steam Pump Co.
Number 3
SERVICE PUMPS .....
.....De Laval Steam Turbine Co.
Number 6
Capacity..3—1000 g.p.m.; 3—2000 g.p.m.
Drive...3—60 hp., 3—125 hp. G.E. motors
FIRE PUMP.....Dayton-Dowd Co.
Number .....1, centrifugal
Capacity.....1000 g.p.m., 100 ft. head
Drive.....Sturtevant 1-stage turbine
FIRE PUMP..Warren Steam Pump Co., Inc.
Number .....1, centrifugal
Capacity.....1500 g.p.m., 125-ft. head
Drive .....
200-hp. G.E. const. sp. induction motor
CHILLED WATER PUMPS.....
.....Warren Steam Pump Co., Inc.
Number.....2—90 g.p.m. each

Turbine Generators and Auxiliaries

TURBINE.....General Electric Co.
Number 1
Type...Mixed-pressure extraction, 5-stage
Capacity.....1500 kw., 0.8 p.f.
Speed .....3600 r.p.m.
Governor .....
Aut. press., to keep extract. pressure const. between 5 and 6 lb. gage.
Steam pressure .....
250 lb. throttle, extraction at 5 lb. exhaust at 28 in. Hg.
CONDENSER .....Ingersoll-Rand Co.
Number 1
Type .....Single-pass
Surface .....1770 sq. ft.
Steam-jet air pumps...Ingersoll-Rand Co.
Type 2-stage
Capacity.....25,000 lb. steam an hr.
CONDENSATE PUMPS....Ingersoll-Rand Co.
Number 2
Capacity .....50 g.p.m.
Drive .....5-hp. G.E. motors
GENERATOR.....General Electric Co.
Size...1875 kv-a., 480-v., 3-phase, 60-cycle
TURBINES.....General Electric Co.
Number 2
Type.....1 stage, non-condensing
Capacity.....750-kw. each, 0.8 p.f.
Speed .....3600 r.p.m.
Steam pressure, throttle.....250 lb. gage
Steam pressure, exhaust.....5 lb. gage
Generators .....
....937 kv-a., 480-v., 3-phase, 60 cycle
Exciter.....Direct-connected, 125 v., d.c.
GENERATOR AIR COOLERS.....
..... Griscom-Russell Co.
STANDBY SETS OR SPARE EXCITERS.....
.....General Electric Co.
Type ..... Motor-generator
Number 2
Capacity.....30-kw., 125 v., d.c.
Drive.....50-hp., 440-v.. induction motor
OIL SEPARATORS.....Wright Austin Co.
LUBRICATING OIL FILTERS.....S. F. Bowser & Co. and Hydroil Centrifugal

Refrigeration and Air Compressors

REFRIGERATING MACHINES .....
.....Carrier Engineering Corp.
Service.....Air conditioning in mill
Number 2
Type ..... Centrifugal
Capacity....1—175-t., 1—210-t. per 24 hr.
Refrigerant ..... Carrene
Drive.....G.E. steam turbine
Steam conditions .....250-lb. throttle; exhaust 5 lb. or condenser
Turbine capacity .....300 hp.
Speed .....3800 r.p.m.
Steam condenser for ref. machs.....
..... Ingersoll-Rand Co.
Number.....1 for 2 turbines
Size.....No. 9, 760 sq. ft.
Carrene condenser, coolers and accessories all part of refrigerating machine.
CONDENSATE PUMPS on Carrier Machs. Condenser .....Ingersoll-Rand Co.
Number 2
Capacity.....15 g.p.m. each
Head .....23 ft.
Drive.....440-v. Westinghouse motors
AMMONIA COMPRESSOR .....
.....Carbondale Machine Co.
Service.....Cooling process water
Number.....1, steam driven
Capacity ..... 75 t.
Drive .....
Stumpf Uniflow Engine, 11 in. by 14 in.
Steam pressure .....
.....Throttle 250 lb., exhaust 5 lb.
Ammonia condenser, receivers, piping and auxiliaries.....Carbondale Machine Co.
AIR COMPRESSORS .....
.....Chicago Pneumatic Tool Co.
Number.....2 (1 steam, 1 motor-driven)
Capacities:
Steam .....1138 c.f.m.
Electric ..... 984 c.f.m.
Steam drive .....
Steam cyl. cross-compound, 250 lb. throttle, 5 lb. exhaust. Speed 225 r.p.m.
Electric drive .....
1 General Electric synchronous motor 440-v., 175-kv-a., 257 r.p.m.
AIR COOLERS.....Griscom-Russell Co.

Electrical Equipment

TRANSFORMERS.....General Electric Co.
Type .....Main power
Service.....Power to filter plant and tie with American Glanzstoff Corp.
Capacity.....3 1000 kv-a. each
Voltage.....480 to 2300
TRANSFORMERS.....General Electric Co.
Service..Station lighting and mill lighting
Number .....
6 (1 bank regular, 1 bank emergency)
Capacity .....50 kv-a. each, 1 bank 480/110 v., 1 bank 2300/110
Emerg. power.....3—75 kv-a. each
Voltage 2300/440
OIL CIRCUIT BREAKERS..General Electric Co.
ELECTRIC METERS AND INSTRUMENTS..
.....General Electric Co.
SWITCHBOARDS.....General Electric Co.

Other Mechanical Equipment

PIPING .....Grinnell Co.
VALVES:
Steam and water.....
.....Lunkenheimer Co.,
.....Chapman Valve Mfg. Co.
Back pressure.....Cochrane Corp.
Atmospheric relief.....Cochrane Corp.
Blowoff .....Everlasting Valve Co.
.....Yarnall-Waring Co.
Safety..Crosby Steam Gage & Valve Co.
Pressure reducing .....
.....A. W. Cash Co.,
.....Kieley & Mueller, Inc.,
.....G. M. Davis Regulator Co.
Pressure regulating .....Cash, Powers, Fisher, Crane, Taylor, Foster
PIPE INSULATION.....Johns-Manville Corp.
BLOWOFF TANK.....R. D. Cole
EXHAUST HEADS.....Grinnell Co.
GRATINGS & STAIRS..Johnson City Foundry
METERS:
Venturi.....Simplex Valve & Meter Co.
Steam, air and water..Bailey Meter Co.
CO_2 (Ranarex).....The Permutit Co.
Indicating pressure gages, pressure and temperature recorders (American).....Cons. Ash. Han. Co., Inc.
STEAM TRAPS..Armstrong Machine Works, ...Strong, Carlisle & Hammond Co.
STEAM SEPARATORS.....Cochrane Corp.
CONSTANT EXCESS PRESS. Regulators (S-C).....The Swartwout Co.
EXPANSION JOINTS:
Condenser.....U. S. Rubber Co.
Pipe line.....E. B. Badger & Sons Co.

inlet, as described in the October 1, 1928 issue of Power Plant Engineering.

Boiler Auxiliaries

Fans, stokers and dampers are under the control of a combustion control system. Automatic feedwater regulators adjust water levels; complete equipment of draft gages, flow meters and other necessary instruments is provided; the entire boiler room shows attention to convenience and reliability of operation. One of its most interesting features, also one of the greatest convenience, is the main steam header, Fig. 6, located at the floor level behind the boilers, to provide quick and easy access to all main control valves. From the operator's standpoint, this arrangement has proved most satisfactory.

Virginia coal, brought to the plant in cars, is dumped and then is distributed to storage by a drag scraper, which also reclaims it when needed. A track hopper, which can be filled direct from cars or by the drag scraper, feeds an apron conveyor that takes the coal to a crusher if necessary, whence it passes on a belt conveyor to the 600-t. steel storage bunker over the boiler firing aisle. A motor-driven weigh larry distributes it to the stoker hoppers.

Ash disposal is by one of the simplest known methods: that of dumping the ash direct to metal-body trucks which can run right into the boiler room basement in a passageway provided for them under the hoppers.

Condensate Forms Bulk of Feedwater

Feedwater for the boilers is mostly condensate from the mill processes, from heaters, condensers and heating system. All this condensate is led back to a hot well, where the necessary makeup water is added under control of a float valve. Since the proportion of makeup water is extremely small, and since it comes originally through the filter plant, it is not chemically treated. From the hot well, two small centrifugal pumps, also controlled by a float, boost the water to the 300-g.p.m. open feedwater heater, which also deaerates and meters the water before it flows to the boiler feed pumps. These are multi-stage centrifugals, designed for operation against 300-lb. head. Two of them are of 200-g.p.m. capacity, one driven by a motor and one by a steam turbine. The third is a motor-driven 350-g.p.m. unit. Constant excess pressure regulators govern the operation of these pumps.

Process Water Demand Controls Design

Turning now to the general conditions of operation of the Bemberg power plant, we find that one of the principal factors influencing the design and, as a result, the operation of the plant, was the necessity of providing large amounts of hot and cold water at various temperatures. Under these conditions, by using a comparatively large number of steam driven machines, sufficient exhaust steam could be provided to heat this water, at the same time returning a large amount of the heat to the boilers in the form of condensate. Also by using condenser circulating water for the spinning mills, large amounts could be saved on pumping costs. A sufficient number of duplicate essential auxiliaries was provided with motor drive so that, in emergencies, boiler feed pumps, circulating water pumps, condensate and other pumps can operate through the tie-in with the Glanzstoff plant referred to above.

Two separate water lines lead from the filter plant at the river; this filter plant has a capacity of 8,600,000 gal. a day. One of these lines goes direct to the mill for miscellaneous service. The other leads into the power house, connecting to the surface condenser of the 1500-kw. mixed-pressure extraction turbine unit. Water coming through this line, after serving as condenser circulating water, flows through two sets of closed feedwater heaters, arranged so that they can be connected in parallel or series or bypassed. Exhaust steam under the control of a temperature controller is admitted to these heaters from the exhaust header to heat this water to 90 deg. F. and it flows then to the spinning mill for process work. This temperature of

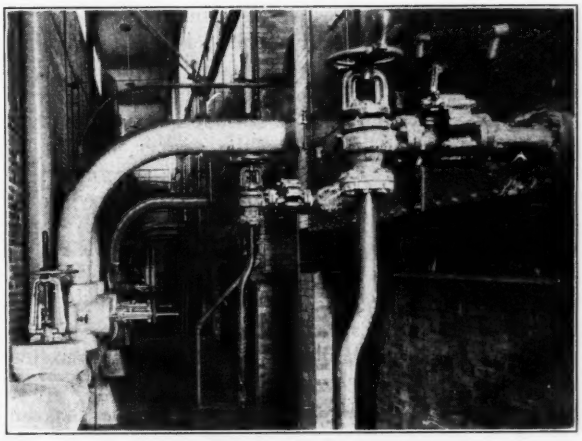


FIG. 6. MAIN STEAM HEADER NEAR FLOOR GIVES OPERATORS EASY ACCESS TO CONTROL VALVES

90 deg. must be maintained within narrow limits and this can be done by varying the connections of the heaters, depending on demand and initial temperature of the circulating water.

Another pair of closed water heaters, under automatic temperature control, draws water from the spray pond circulating system, heats it to 190 deg. and it is then pumped to the mill for process and service water.

Cooling Water Supply From Spray Pond

To furnish water for the generator air coolers, oil coolers, inter-coolers of the air compressors, condensers of the refrigerating machines, condenser of the turbines driving the centrifugal compressors and similar purposes, a spray pond circulating system is employed. In the turbine room basement are three spray-pond circulating pumps taking their suction from the spray pond reservoir and forcing this water to a header from which the various coolers and condensers just mentioned draw it, discharging it to another line leading back to the spray pond. From this circuit also the makeup boiler feedwater is taken. A connection between the circulating water header and the mill service water line is provided for emergency use together with a connection to the city water main. For boiler feed makeup and losses in the spray pond system, a float valve connection to the mill service line maintains a constant level in the spray pond.

From the mill service water line a connection is taken off for two fire pumps, a 1000-g.p.m. turbine-driven centrifugal and a 1500-g.p.m. motor-driven centrifugal. Besides this, for emergency service, an 8-in. city water line leads in to the fire pumps and fire protection system, while another city water line leads to the 90-deg. water heaters so that, if the supply of condenser circulating water from the 1500-kw. unit should fail for any reason, a supply of spinning water could be maintained to the mill.

Steam-Driven Units Exhaust to Header

All steam for the water heaters noted above is drawn at 5 lb. pressure from a 24-in. exhaust header running the length of the turbine room basement. Into this header all the steam-driven auxiliaries exhaust; the extraction turbine supplies part of its steam at 5 lb. to this header in winter time and receives steam at 5 lb. pressure in its low-pressure stages in summer. Stoker engines and turbines, fan turbine, boiler feed pump turbine, steam-driven air compressor, ammonia compressor, steam turbines of centrifugal refrigerating machines—all exhaust into this header. It can be seen, therefore, that by operating the proper number of steam-driven machines or their alternate motor-driven units, the proper heat balance can be obtained to fit the demands of the factory without wasting any steam to the atmosphere. To add further flexibility to the scheme, the turbines driving the centrifugal refrigerating compressors can discharge to a condenser when their exhaust steam is not needed; this condenser takes its circulating water from the spray pond system.

Chilled water at 50 deg. and ice are furnished by the steam-driven ammonia compressor, while the centrifugal compressors supply cooled water at 40 deg. used for air conditioning. Thus the exhaust steam from these three refrigeration units is available whenever the mill is operating, as well as from one or more of the generating units, leaving the balance to be obtained by proper use of auxiliaries.

All condensate from condensers, heaters, drips, heating system and other sources, as well as returns from the mill process, is trapped back to the hot-well for use as boiler feed. A large proportion of the process steam used in the mill is employed in such a way that it can be condensed and returned. Oil separators are used on steam and exhaust lines in which there may be oil, to assure clean condensate for boiler feed. This is also assured by the large amount of turbine exhaust.

Steam at 125 lb. pressure for process work is supplied direct to the mill from the main steam header through reducing valves and as the condensate from this is all returned to the boiler feed, the loss is small. Compressed air goes direct from the receivers to the plant at 100 lb. pressure.

All the piping for carrying steam, water, compressed air and the electrical conduits runs from the power house to the chemical building and mills through an underground passageway.

Flow meters on all steam, air and water lines record the amounts used for the various industrial purposes. Temperature and pressure recorders and other necessary instruments give full information for securing the proper heat balance conditions to meet the industrial conditions of the rayon plant.

The power plant was designed for the American Bemberg Corp. by Lockwood Greene & Co., Inc., the construction work being supervised for the latter company by R. J. H. Worcester and the design by S. B. Lincoln. Max Korff is vice-president of American Bemberg Corp., H. F. Marthaus is engineer and S. P. Sutton is power plant engineer in direct charge of operation. We are indebted to all the men noted above for the most cordial coöperation in visiting the Bemberg plant and in obtaining photographs and data for this article.

Coal Production in Pennsylvania in 1928

Pennsylvania continues to lead all other states in the total value of coal production, according to the latest figures compiled by the United States Bureau of Mines, Department of Commerce. The total value of the coal produced by the mines of the state in 1928 was $643,533,000; of this, $393,638,000 was contributed by the anthracite mines and $249,895,000 by the bituminous mines. In comparison with the year preceding, the total value shows a decrease of 7 per cent and the total tonnage a decrease of 3 per cent.

Production of bituminous coal was 131,202,163 t. Fayette County continued to lead all other bituminous counties in the State with a total production of 29,564,000 t. Next in order came Westmoreland County with 16,729,000 t. Cambria County with 15,012,000, Washington County with 14,776,000 and Allegheny County with 13,393,000 t.

In comparison with 1927, the record for 1928 shows a tendency to concentrate production of bituminous coal in a smaller number of more efficient mines. The number of commercial bituminous mines in operation declined from 1831 to 1557 but the number of Class 1 mines; that is, mines producting 200,000 t. or more, increased from 174 to 189. The output per man per day increased from 4.26 t. to 4.52. A smaller number of men were employed but those remaining on the payrolls were given more steady employment. The total number at work declined from 153,829 in 1927 to 133,414 in 1928 but the average time worked by the mines in operation increased from 203 days to 218 days.

The year 1928 was one of lessened activities in the bituminous coal industry, and Pennsylvania operators shared the general countrywide conditions. The average price f.o.b. mines in 1928 was $1.90 per ton, or 25 cents less than in 1927.

Hydraulic power plant structures, like most other engineering structures, are a compromise between first cost and efficiency. The tendency is to reduce the overall dimensions to cut down excavation and concrete. Shallow or narrow water passages and high velocities cut down the available head by high friction losses and exit velocity losses. For low head plants, a desirable velocity through the intake racks is about 2 ft. per sec. while through the discharge passages this may be doubled, giving a velocity of about 4 ft. per sec. The substructure of such plants must serve as both a foundation and water passage. Piers and columns are sometimes necessary in the water passage and these cause additional loss of head which, because of cost considerations, cannot always be avoided.

High Pressure Industrial Power Plant Costs

In an 1800-Lb., 9000-Kw. High Back Pressure Development It Was Found That the Entire Plant Could Be Completed for Less than $100 per Kw. of Capacity. By John F. Ferguson*

COMPARED WITH a development of standard pressures, the combination of high or extremely high initial steam pressure with moderate or high working back pressure, in connection with industrial power systems, offers advantages from the standpoint of initial cost and final development which should not be overlooked by the modern industrial engineer and executive.

As a means of dividing the range of steam pressures into definite but more or less arbitrary classes, it is well to designate for convenience the following divisions:

Up to 250 lb per sq. in., standard or moderate pressure;

From 250 to 600 lb. per sq. in., medium pressure;
From 600 to 1400 lb. per sq. in., high pressure, and
Over 1400 lb. per sq. in., extreme pressures.

Regardless of pressure considered the investment required for an industrial steam power development is dependent to some extent upon local and specific conditions, some of which are: excavation, bearing surface for foundations (rock, clay or piling), space available, value of real estate, flexibility in operation, reserve capacity in steam and power units and variation in steam and power demands. The investment as affected directly by higher steam pressure is dependent upon the complete boiler units, prime movers, piping, feed pumps, stage heaters, ratio of steam to power demand and operating efficiency demanded of both steam and power generation.

Costs of High Pressure Equipment Will Decrease

In considering a high or extreme steam pressure development the item which probably looms up as the greatest obstacle is the first cost. It is true that some of the public utilities entering this high pressure field early paid enormous prices for some parts of the installation but they no doubt consider the undertaking well worth the extra investment, not so much from the increased earnings of the first installation, as from installations to follow.

Public service corporations are generally in a better position than industrial concerns to exploit these new fields, for the reason that they have no competition in business, can generally have their selling prices adjusted to fit their expenses and can borrow money easier to allow them to carry out a new undertaking.

In industrial power systems with moderate and comparatively high working back pressures of prime movers and manufacturing system, much more can be gained by high and extreme initial steam pressures, than in condensing central station systems. To permit a more universal adoption of high and extreme pressures, particularly in the industrial field, lower first costs than so far advanced must be presented.

When we consider high and extreme pressures with the object of greater efficiencies, we are equally justified in seeking lower exit gas temperatures, better combustion by the use of better fuel burning equipment, improved feedwater conditions, more expensive arrangement of feedwater heating, more expensive equipment in plant control and regulation, and a better type of prime mover.

These items contribute considerable to the cost of the higher pressure plant, so that one may be misled by the difference in cost of a standard pressure and high or extreme pressure plant, when in reality only a part of increase is actually due to the higher steam pressures. If we considered higher pressure boilers, feed pumps, piping and prime mover only, then the additional cost of the higher pressure installation would be small indeed, ranging from minus 10 to plus 30 per cent of the total cost of the entire plant, depending upon the class of plant and pressures involved.

Costs Gradually Increase with Pressure

In boiler construction there is a gradual rise in initial cost, from 200 to about 500 lb. pressure; than a rapid rise to around 650 or 700 lb. (in going from riveted to seamless and forged drum construction), while from this point up to 3200 lb. pressure the increase is again gradual.

In the selection of equipment, general arrangement and layout, much can be done to reduce the initial investment or obtain higher overall efficiencies or both. Boiler designs and arrangement of the heating surface, have a great bearing on the cost of boiler units, some designs of complete units may involve almost twice that of other designs of equal capacity and working efficiency.

Some of the desired features of a boiler unit for extreme pressures are: compactness of the combined unit; small diameter of drums and tubes to keep down the weight; long tubes to reduce the number of tube joints; comparatively small boiler heating surface arranged for absorbing a large amount of heat per unit of surface; comparatively large heating surface exposed to furnace; large economizer section, and extra large air preheating surface. The proportion of the combined unit for extreme pressures and high overall boiler efficiency may approach the following proportions:

Boiler (proper)	10 per cent
Furnace water walls	5 per cent
Superheater	7 per cent
Economizer	18 per cent
Air preheater	60 per cent

Best Condition Found Where Power and Steam Loads Balance

High cost of piping for higher pressures in steam lines is partly offset by the smaller sizes required to deliver an equal weight in steam.

It is well to base comparisons on the total capacity

*Ferguson Engineers, Chicago, Ill.

of the plant, rather than on the load of the plant or the output in kilowatt-hours. Assuming an industrial plant where a fair amount of steam is used 24 hr. a day at a low pressure, say 20 lb. absolute, in process of manufacturing with a power demand sufficiently high so that all the byproduct power available from any pressure can be utilized in the system, we arrive at a development giving the lowest unit cost of capacity. The lowest unit cost of power is not necessarily obtained from the lowest unit cost of capacity unless it represents the greater capacity.

If developments of the higher class ranging from 200 lb. pressure up are figured out using different types of prime movers working under fair load conditions, low and moderate back pressures and average fuel costs, it will be found that the lowest unit cost of power capacity and lowest unit cost of power will occur at about 500 lb. working steam pressure for a turbine unit and around 1400 to 2000 lb. pressure for a steam engine

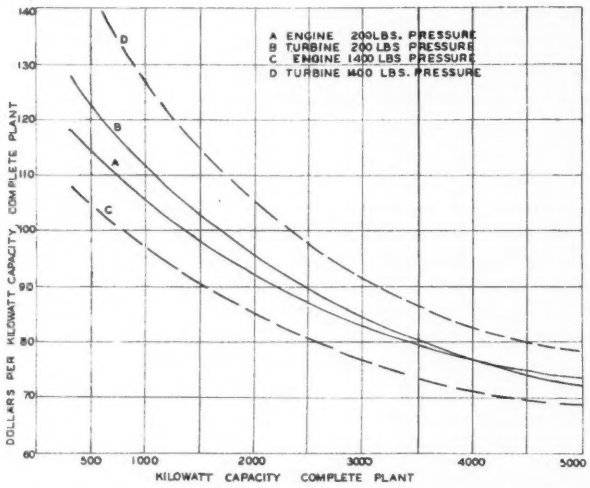


FIG. 1. COMPARATIVE COSTS OF COMPLETE STEAM-ELECTRIC PLANTS FOR DIFFERENT DESIGNS

unit. If an exhaust steam pressure to the manufacturing system of around 100 lb. is assumed then the lowest unit cost of capacity and lowest unit cost of power will be around 1400 lb. or less for the turbine unit and from 2000 to 3200 lb. pressure for the engine unit. The reason for this difference between the turbine and the engine units is on account of the increasing efficiency of the engine unit over the turbine unit as the initial steam pressure is increased or the working back pressure is increased.

Prime Mover Efficiency May or May Not Be Important

In some industrial steam and power developments, particularly where the steam demand is high and the power demand is low, high pressures and high efficiency of prime movers may be of little or no advantage. When it is necessary to go into high or extreme steam pressures, higher efficiency in prime movers will mean considerable, for the difference in efficiency of the prime mover may mean a considerable difference in boiler pressure to obtain equal results.

For instance, some types and sizes of engine units taking steam at 400 lb. pressure and exhausting at about 20 lb. absolute, will deliver more power per 1000 lb. of steam than some type of steam turbines of equal capacity taking steam at 1400 lb. and exhausting at the same back pressure as the engine unit. While the less efficient prime mover would cost less money than the more efficient unit, the boiler plant accompanying the less efficient unit to produce an equal amount of power, would cost more, by many times, than the difference in prime mover costs. For this reason more efficient prime-mover units will generally reduce the cost of high pressure industrial power plants.

Costs Will Decrease as More Units Are Sold

Prime movers built for higher pressures do not always add to the cost of the unit. Most of the high pressure units so far built have been more or less special in design and construction and demanded a high price to cover some of the development costs. In turbines, high pressure involves more cast steel and forged steel construction so that the price will generally be higher, even if they were produced as standard units.

Engine units will involve more cast steel or forged steel construction also, but some of these parts together with the machine work on them, will be so reduced to proportions, that the initial cost for higher pressure engines would be lower than for standard pressure units, if they were produced as standard construction, instead of special as at present.

Total investment or unit capacity costs, of any high or extreme pressure industrial steam power development will, as stated before, depend upon the number and type of boiler and prime mover units required. Throughout this article, an average boiler efficiency of not less than 80 per cent under working load conditions has been assumed. The initial investment will generally be lower with larger and single unit installations, but the flexibility, reliability and cost of operation will generally favor two or more units in both boilers and prime movers. The relative costs of the one, two, three, four or more unit plants of equal total capacity will be in the ratio of about 1, 1.22, 1.3 and 1.35.

Assuming a single unit coal burning plant with total boiler capacity to correspond with prime mover and generator capacity, the unit cost of power capacity will within certain limits be reduced, as the capacity, pressure and efficiency is increased.

Unit Costs Decrease with Capacity of Plant

In Fig. 1 are shown graphically, the comparative costs of complete steam-electric power plants of varying capacities, that may be expected under good design and fairly favorable construction conditions. In these curves plants for both standard and high pressures and both types of prime movers are represented. Solid lines represent standard pressures or 200 lb. and broken lines extreme or 1400 lb. pressures.

These curves were figured for steam conditions of 17 to 20 lb. abs. back pressure on the prime movers, as often found in industrial plant operations.

In Fig. 2 are graphically illustrated comparative costs for single unit complete steam-electric power plants, complete boiler plants and prime mover units, for any steam pressure throughout the range, from the standard pressure of 200 lb. up to the critical steam pressure of 3200 lb. per sq. in.

As a basis of comparison, costs for standard 200 lb. pressure plants and units are considered as 100 per cent and other costs presented in relation to this. These plants and units are figured for exhaust steam conditions of from 17 to 20 lb. abs. back pressure as before and for fair-sized industrial power units of around 2000 kw. capacity. To obtain cost or relative cost of plant with two or more boiler and prime mover units, multiply the indicated costs and relative costs by the cost ratios for one or more units as referred to earlier in the article.

While some of the costs and relative costs indicated are perhaps lower than what many have been led to believe or have paid, yet they represent what can be expected or accomplished in the advanced, more efficient and more economical class of industrial steam power development.

Actual Costs Should Not Vary Much from Those Given

In the unit cost of power capacity referred to, no account has been taken of land value of the space occupied but includes buildings and interest on investment during construction. The actual cost may vary perhaps from 10 per cent below to 10 per cent above those given, in order to cover most favorable or most unfavorable conditions. Where such costs are inclined to be more than the additional 10 per cent allowed, it is evident that the conditions of construction are extremely bad or the plant is intended to meet certain extreme efficiencies or conditions in operation, or the plant is entirely out of proportion in building and equipment design or overloaded with engineering, construction or material costs.

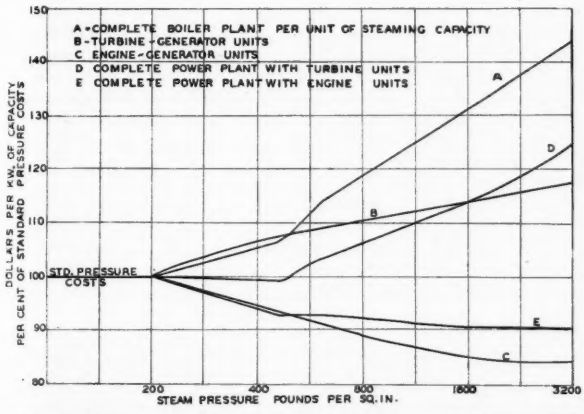


FIG. 2. COMPARATIVE COSTS OF SINGLE-UNIT COMPLETE STEAM-ELECTRIC PLANTS FOR THE FULL PRESSURE RANGE

When some of the equipment and materials for the high and extreme pressures become standard or more generally used, the initial investment for high and extreme pressures will be somewhat reduced and will make these pressures more generally adopted by industrial plants than by public service plants.

In an 1800 lb. industrial power development, promoted by the writer, in which the steam required for manufacturing purposes at different pressures, averaged around 75 lb. abs., based on quantity demand, it was found that the total cost of the complete power plant would be much less than $100 per kw. capacity installed, including new buildings and new development work for boilers, prime movers and other equipment for a total development of 9000 kw. capacity, involving three boiler units and three engine units.

It will be noted that the cost per kilowatt of capacity, is lower for engine units with high and extreme pressures at all capacities, than for turbine units, on account of the much higher efficiencies of the engine unit under these steam conditions, a fact which helps reduce the boiler plant costs much below those of the turbine installation.

It can also be noted that increasing the initial pressure does not necessarily increase the unit cost per kilowatt of plant capacity, particularly with engine units. In fact, it appears as though the unit cost continually falls off up to 3200 lb., although this decrease is small from 2000 to 3200 lb. initial pressure on low back pressure conditions.

Higher back pressures will increase the unit cost of plant capacity, and increase or decrease of unit cost in per cent, due to higher initial pressure, is greater with the higher back pressures.

Stokers Made Coal Screenings Salable

Development of the power plant industry, particularly the mechanical stoker, has been largely responsible for the value of coal screenings, that is, sizes below 1½ in. Coal preparation and washing plants have been in use for many years, although there has always been some question whether the increased value of prepared coal was due to washing or sizing.

In the early days, the mine run was passed over crude screens and the screenings sent to waste. Since these fine sizes are now salable, elaborate screening equipment and tipple plants are necessary. Coal from the hoist weigh hopper is passed over a series of screens, the finest one first, succeeding ones with gradually increasing openings.

Coal passing over the last screen is in the form of lumps 6 in. or over. Larger sizes are picked by the hand but screenings usually go directly to the railway cars. Nine standard mine sizes are now produced in the middlewest. They are:

Size	Name
Over 6 in. screen	Lump
Thru 6 in. over 3 in	Furnace
Thru 3 in. over 2 in	Small egg
Thru 2 in. over 1½ in	Stove (No. 2 nut)
Thru 1½ in. over ¾ in	Chestnut (No. 3 nut)
Thru ¾ in. over ⅜ in	Pea (No. 4 nut)
Thru ⅜ in.	Carbon (No. 5 nut)
Thru 2 in. and smaller	2-in. screenings
Thru 1½ in. and smaller	1½-in. screenings

Following the recent growth of powdered fuel for steam making purposes, the small sized screenings, that is, ⅜ in. and under, is becoming of value as it does not have to be crushed and requires a minimum of power for pulverization.

Back pressure turbines are more efficient thermally because there is no condenser loss.

Steam Power Practice in the Glass Industry

By C. C. Thatcher
PITTSBURGH PLATE GLASS CO., KOKOMO, IND.

SUSCEPTIBLE to a high state of electrification, the glass industry has made rapid strides in the development of power plants for the generation of power used within the plant. With the development of isolated plants, operating practically as an independent unit or department, and the tendency toward consolidation of large business units to better meet the present economic and marketing conditions, the need for a highly organized power plant department and suitable records of operation becomes urgent.

As the number of plants operated by a single company increases, the records must fill two important requirements; they must give sufficient data to enable the supervising engineering department to compare the performance of the plant with other plants and past performance while they must also give sufficient data to enable those directly responsible for plant operation to interpret correctly variations in performance or efficiency.

In one particular organization the first requirement is met by the record form shown in Fig. 1. This form, a summary of weekly operation, shows the total amount of water used, the net evaporation, pounds of coal burned, the power generated, rating at which the boilers were operated, generating units in service and other data such as steam pressure and temperature. With these data the performance of the plant in terms of pounds of water evaporated and kilowatts generated per pound of coal can be checked and when comparing different plants, allowances for differences in steam pressures, temperatures and load can be made.

The second form shown in Fig. 2 is much more complete; it shows the power generated by each unit during each watch; the total generated for the day and the total net power available for distribution after power used within the station is subtracted.

In the second division of this form, the summary of the day's operation is available, showing the total amount of coal used, steam generated, net electric power generated and performance of the plant both as a unit and individually, with the performance of the boiler room expressed as pounds of water evaporated per pound of coal and the performance of the station expressed as pounds of coal per kilowatt-hour distributed.

If the performance for the day falls noticeably below the cumulative performance for the month, it is at once apparent to the chief engineer by comparing the figures in two adjacent columns. If the difference is not apparent from load conditions shown in the summary he can take the matter up immediately with individuals of the operating force before they have time to forget. It is usually easy to explain irregularities in operation a few hours after whereas after a few days time the matter is entirely forgotten.

Records of the employes on duty at a given time are extremely important and should always be kept so that they are immediately available if questions regarding operations come up at a later date. Of course, the few records given above are not all that can and should be kept, nor do they indicate all the meters and instruments that should be used but they do show the essential data which should be available for purposes of supervision where the important thing is not

Form 453

WORKS NO. 8

BOILER PERFORMANCE FOR Week ENDING Feb. 17, 29

METER READING ON ABOVE DATE LBS. WATER	34,933,000
PREVIOUS METER READING LBS. "	17,667,000
CONSUMPTION FOR WEEK LBS. "	17,266,000
FILLING AND TESTING BOILERS LBS. "	53,160
LBS. OF WATER EVAPORATED	17,212,840
LBS. WATER DEDUCTED FOR TEMP. CORRECT.	.....
CORRECT EVAPORATION	17,212,840
LBS. COAL CONSUMED	1,972,000
LBS. WATER PER LB. COAL, ACTUAL	8,728
LBS. WATER PER LB. COAL, FROM & AT 212°	.....
NET K. W. H.	812,300
LBS. OF COAL PER K. W. H.	2.427
AVERAGE STEAM PRESSURE	220#
AVERAGE FEED WATER TEMP.	210-F
AVG. NUMBER BOILERS PER DAY	3
" " " BANKED	1
" BOILER H. P. PER DAY RATED	1,995
" " " " " " DEVELOPED	3,774
BOILER HORSEPOWER % RATING	1.89%
TEMP. CORRECTIONS FOR WEEK %	

HOLD OVER

EVAPORATION	788,000
LBS. OF COAL CONSUMED	109,000
TEMPERATURE CORRECTION %	.....
LBS. WATER PER LB. COAL, ACTUAL	7,229
NET K. W. H.	15,570
LBS. COAL PER K. W. H.	7.000
LBS. COAL PER K. W. H. FOR ENTIRE WEEK	2.513

NO. HOURS TURBO GENERATORS OR ENGINES IN SERVICE

NO. 1	
NO. 2	152
NO. 3	168
COST PER K. W. H.	

REMARKS: Automatic tested #2turbine by overspeeding tripped at 3880 R.P.M. 280.R.P.M. over running speed.

A. J. Cassell C.E.

FIG. 1. THIS POWER PLANT REPORT GIVES A SUMMARY OF THE WEEK'S OPERATION

how much to show but how much can be left off and still show the essential data.

In every plant there are innumerable places where instruments must be used to guide the operators toward efficient operation and wherever possible it is advisable to have these kept in some permanent or semi-permanent form. Such records and data, however, are of interest and value to the operating department only and, if included in the summarized report of the station performance, tend to cause confusion.

PITTSBURGH PLATE GLASS CO., KOKOMO, IND.

DAILY REPORT—POWER STATION

D1247 SHEET 3 DATE Feb. 21 192?

WATT HOUR METERS

GENERATORS	6 A. M.	2 P. M.	K W H	10 P. M.	K W H	6 A. M.	K W H	TOTAL
" No. 1	344900	366300	21,400	387900	21,600	409000	21,100	64,100
" No. 2	478400							
" No. 3	616800	639600	22,800	662500	22,900	685500	23,000	68,700
TOTAL GENERATOR			44,200		44,500		44,100	132,800
EXCITER MOTOR	46490	46810	320	47120	310	47440	320	950
SERVICE STATION	20250	21150	900	22050	900	22980	930	2730
NET GENERATED					43290		42,850	129,120
FEEDERS No. 1	960700	981600	20,900	003200	22,600	026300	23,100	66,600
" " 2	153400	161200	7800	170100	8900	177600	7500	24,200
" " 3	235000	245200	10,200	254500	9,300	263200	8700	28,200
FACTORY SERVICE	23280	26500	3,220	29190	2,690	31850	2,650	8,570
FUT Plant Lighting	283100	—	—	283200	100	283400	200	300
"								
TOTALIZING								
PEAK LOAD								

VENTURI METER

6 A. M.	44878		
2 P. M.	45758	LBS.	890
10 P. M.	46674	LBS.	916
6 A. M.	47586	LBS.	912
TOTAL			
OIL	USED		KIND
TURBINE No. 1			
" No. 2			
" No. 3			
F. O. FANS	19 gal	DTE light	
PUMPS	2"	"	"
STOKER ENG.			
STOKERS	1 gal.	VIS. AA	
MISC.			

SUMMARY OF OPERATION

	6 A. M. TO 2 P. M.	2. P. M. TO 10 P. M.	10 P. M. TO 6 A. M.	FOR DAY	MONTH TO DATE
K W H DISTRIBUTED	42,980	43,290	42,850	129,120	2,448,720
LBS. OF COAL USED	108,000	108,000	104,000	320,000	6,120,000
LBS. OF WATER USED	890,000	916,000	912,000	2,718,000	54,715,000
LBS. COAL PER K W H	2.51*	2.49	2.43	2.48	2.50
LBS. WATER PER K W H	20.707	21.13	21.28	21.05	22.36
LBS. WATER PER LBS. COAL	8.24	8.33	8.77	8.50	8.91

OIL ON HAND

KIND	AMOUNT

EMPLOYEES ON DUTY

ENGINEERS	ON	OFF	HOURS
C. Record	7:00 A.M.	3:00 P.M.	8
E. Thatcher	3:00 P.M.	11:00 P.M.	8
V. Hollis	11:00 P.M.	7:00 A.M.	8

FIREMEN	ON	OFF	HOURS
J. Miller	7:00 A.M.	3:00 P.M.	8
G. Foust	3:00 P.M.	11:00 P.M.	8
D. Hardin	11:00 P.M.	7:00 A.M.	8

OILERS			
A. Duke	7:00 A.M.	3:00 P.M.	8
J. Brunscore	3:00 P.M.	11:00 P.M.	8
J. O'Neil	11:00 P.M.	7:00 A.M.	8

HELPERS

REPAIRMEN

LABORERS

REMARKS:

SIGNED A. J. Cassell CHIEF ENGINEER

FIG. 2. METERS READ AT THE BEGINNING AND END OF EACH SHIFT SHOW THE PERFORMANCE OF THE PLANT FOR THAT SHIFT AND FOR THE DAY. IN THE SUMMARY OF OPERATION THE PERFORMANCE OF THE PLANT FOR THE DAY IS DIRECTLY COMPARABLE WITH THE CUMULATIVE TOTALS FOR THE MONTH

Selecting the Proper Motor for the Job

CHARACTERISTICS OF MOTOR TYPES THAT MAKE THEM SUITABLE FOR DIFFERENT SERVICE CONDITIONS. BY R. W. ZEHNER*

SELECTION of the proper motor for a given job is oftentimes a difficult problem, yet it is one deserving the utmost attention. So many factors enter the problem that no general rules can be formulated and it is possible only to point out a few guides which in themselves will bring other related ideas to the fore and assist in arriving at the best possible result.

Proper application depends upon a thorough grasp of the local conditions, a knowledge of the proper duty for various types of motors, and a consideration of the economic aspects of the situation.

TABLE I. SUMMARY OF MOTOR CHARACTERISTICS

	Induction Motor		Synchronous	Direct-Current		
	Squirrel Cage	Wound Rotor		Shunt	Series	Compound
Starting Torque	High	Extra High	Medium	High	Extra High	High
Current Required at start	Medium	Moderate	Medium	Low	Medium	Medium
Overload Torque	High	Medium	High	High	Very High	High
Speed	Constant	Adjustable	Constant	Adjustable	Variable	Adjustable
Manual Control	Simple	Fairly Simple	Simple	Simple	Simple	Simple
Power Factor	Good	Fair	Controllable	.....	.....	.....
Efficiency	Good	Fair	Very Good	Good	Good	Good
Cost of Maintenance	Very Low	Low	Low	Moderate	Moderate	Moderate

Under the head of local conditions will appear:

1. Kind of power supply, a.c. or d.c.
2. Source of power supply, whether isolated plant or central station
3. Location of proposed motor. Is it to be near the generator or at a distant point? Will new cables be installed or old cables used? Are the old cables, if used, loaded to capacity?
4. Is the power supply adequate, or
   (a) Is generator operating at full load at present or
   (b) Is the transformer bank loaded to capacity at present?
5. Will the starting current of the proposed motor cause a dip in voltage by
   (a) Overloading feeder circuits?
   (b) Overloading the generator?
6. Is motor to be located in a place which is
   (a) Dirty?
   (b) Damp?
   (c) Excessively warm?
   (d) Contaminated by fumes of acid, alkali, or gas?
7. Is the service continuous or intermittent?

Factors listed under 6 or 7 should be reported to the manufacturer as they make a special motor necessary.

Torque Requirements

Certain applications will be found where a high starting torque is required, but the running torque is low. In such a case, while a motor might be selected amply large to drive the load, it would never be able to start. An example of this would be a rubber mill where the motor is required to be able to start with rubber in the rolls. This requires a high turning effort to start but once the rolls have been started the torque requirements are greatly reduced.

Break-down or pull-out torque must also be considered. For example: a motor driving a punch may pull out if the flywheel on the punch is rather small and the metal punched is heavier than that for which the machine has been designed.

In every case, the drive must be fitted to the load. If speeds are variable, the power required at the different speeds must be carefully determined. Care should be exercised in selecting a motor ample for the requirements. Too small a motor in all probability would be subject to overloads which might result in overheating and a burn-out of the motor. On the other hand, motors should be operated near their rated output for maximum efficiencies.

Variable speed may be required; for example, consider a blower which it is desired to run at half speed to reduce the volume. Another example would be a motor driving a textile machine where certain parts of a process can be carried on more rapidly than others and the requirements call for constant speed at a number of points over a rather wide range.

Principal types of adjustable speed drive available are: direct-current with motor field control; direct-current with generator field control (Ward Leonard); a combination of motor field control and Ward Leonard control; and wound-rotor type induction motors.

The selection of suitable motors requires not only complete information on the power required to drive each group of machines or each machine individually, but also a thorough knowledge of the inherent characteristics of the different types of motors. The more essential characteristics of both alternating and direct-current motors insofar as they affect their applications will now be pointed out.

Direct-Current Motors

There are three common types of direct-current motors: shunt, series and compound wound.

Shunt motors have high starting torque and practically constant speed varying only slightly with load changes. The speed may be adjusted by varying the field strength or by changing the voltage impressed on the armature.

Changing the armature voltage does not change the full load torque. This method is, therefore, a constant torque method and should be used for applications where the torque does not change with load. Usually the motor is designed for the highest speed, and lower speeds are obtained by inserting resistance in the armature circuit. Of course, this results in low economy at low speeds and the speed regulation at low speeds may also be very poor.

A separate motor-generator is sometimes used for supplying the variable voltage for the variable-speed motor. This is the Ward Leonard System, which is satisfactory but expensive. The control is simple and reliable and a wide speed range can be obtained. It is used in special applications for such service as large hoists.

* Engineering Assistant, Elliott Co., from an article in Powerfax.

Shunt field control is the simplest method of speed control and consists merely of inserting resistance in the shunt field circuit. The speed variation is limited and a standard motor will operate only over a range of about 30 per cent. Such an arrangement is not a constant torque but rather a constant horsepower method as the torque falls as the speed increases.

Where a wide range of speed control is required, the best results are secured by a combination of the two methods.

Series motors have a powerful starting torque without requiring a large demand of energy. Such motors should be geared or direct-connected to their loads, since if allowed to operate at no load, a dangerously high speed will be attained.

TABLE II. TABULATION OF MOTOR APPLICATIONS RECOMMENDED FOR DIFFERENT TYPES

	Direct Connected	Belted	Geared	Coupled through Clutch
Air Compressors	~ cpd	sh • ~	sh • ~	
Ammonia Compressors	~ cpd	sh • ~ cpd	sh • ~ cpd	
Cent. Pumps	cpd ~ •	cpd • ~	cpd • ~	
Blowers	~ • cpd	cpd • ~	cpd • ~	
Fans	~ • cpd	~ ⊕ • cpd	~ ⊕ • cpd	
Line shafts	cpd • ⊕ ~	⊕ • cpd ~	• ⊕ cpd ~	~
Grinders	• sh cpd	• sh cpd	• sh cpd	
Woodworking Machinery	sh cpd	sh cpd	sh cpd	
Textile Machinery	sh cpd	sh cpd	sh cpd	
Rubber Mills	• ~ ⊕			~
Tube Mills	• ~			~
Ball Mills	• ~			~
Crushers	• ~			~
Generators	• ~			
Paper Mill Machinery	• ~			~

A.C. Motors: Squirrel Cage Induction ~; Wound Rotor Induction ⊕; Synchronous •

D.C. Motors: Shunt sh; Compound cpd; Series ser.

Speed control of the series motor varies with the load but may be adjusted by changing the impressed voltage. This is usually done by inserting resistance in series with the motor. Usually the applications are those requiring intermittent duty, where such a method is economically possible.

Compound motors have both a series and shunt winding, combining the desirable features of each. They are usually found where the starting load is heavy and the speed approximately constant while in operation. The speed control may be the same as that used for the shunt motor and the speed regulation is particularly good.

Alternating-Current Motors

Induction motors are the most important alternating-current type and they are found in two types:

a. The squirrel-cage type, which is used for constant speed service. It has a high starting torque and a high overload torque and as a unit, it is the most rugged and serviceable of all motors.

b. The wound-rotor type, which is used for services requiring an extra high starting torque combined with moderate current requirements. Such a motor may be used for variable speed service and operated over a range from full speed down to half speed. As a rule, however, wide ranges and low operating speed should be avoided where possible.

Synchronous motors have a constant speed and a high value of overload torque. The power factor which is under control may be 100 per cent, leading or lagging as desired and the efficiency is high over a wide range of load.

Cost Must Be Considered

In nearly every case, the question of costs must be considered. In machine tool work, wood working machinery and similar service, two systems of drive are generally used; namely, group and individual. The question of whether or not group or individual drive is to be installed is largely a financial one, and each case must be properly analyzed. Individual drive necessarily means a large investment but, in nearly all cases, a much greater income will be realized than if line shaft were employed.

The selection of direct-connected, belted or gear drive sometimes is determined by economic considerations. For example, for fan drive it is often possible to use a smaller or less costly motor by the use of belt or gear drive when the fan speed is higher than usual for a motor of the same horsepower. Again, in compressor drive, the ideal motor drive is direct connection, except in very small installations; however, belt or gear drive may be used in case of larger installations of a temporary nature, where economy of power and floor space is not imperative or where first cost and delivery must be considered.

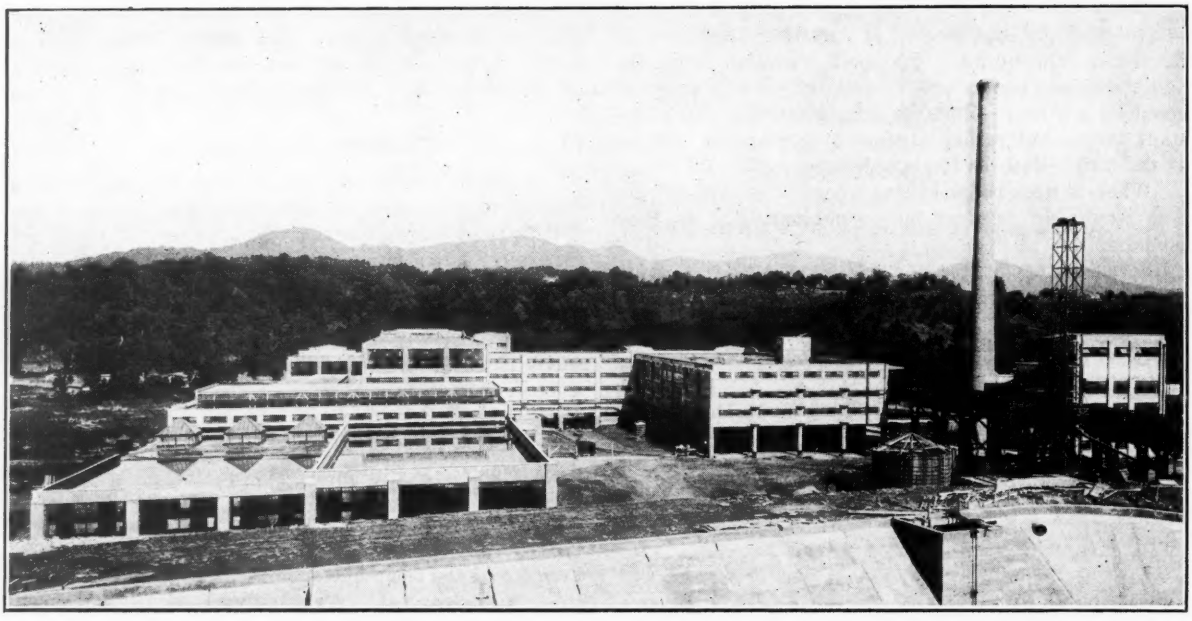
High efficiency is obviously desirable so a motor should be selected which operates normally near full load and which in addition meets the maximum torque requirements. Tables I and II give a list of applications which are considered good practice.

Coal was first discovered on the North American continent by Joliet and Marquette in 1673. This discovery was made in what is now the state of Illinois and, although only the approximate location is known, it is believed to be between the present cities of Utica and Ottawa.

Development of this coal which was, compared to the eastern anthracite, low grade, was delayed, due to the lower quality, the thin seams with corresponding mining difficulties and the comparatively small demand. Industrial growth in the middle west, especially, after the development of the electrical industry, changed this condition, however, and now the deepest coal mine in the United States, 1020 ft., and the largest coal mines in the world are located there.

Practically all mines in this territory are electrified, electric haulage, electric car dumpers, electric hoists and motor-driven fans comprising the largest part of the load. Hoist service is particularly severe and the motor-generator sets serving them are always equipped with large flywheels to keep the speed and voltage up when the hoist starts.

Production of electric power in the United States by public utility power plants, as reported by the Geological Survey, Department of the Interior, reached a total in June, 1929, of 7,768,790,000 kw-hr., of which 4,697,034,000 kw-hr. were produced by fuels and 3,071,756,000 kw-hr. were produced by water power. The total is 14 per cent greater than that for June, 1928.



Industrial Power Plant Practice in the Southeast

IN THE TEXTILE, PAPER, STEEL AND OTHER IMPORTANT INDUSTRIES OF THIS DISTRICT, PROCESS DEMANDS ARE MET BY UP-TO-DATE BOILER AND TURBINE INSTALLATIONS

IN THIS article, data will be given regarding unusual and interesting features of a number of notable power plants in the Southeast serving large mills that epitomize important industries of the region, such as iron and steel, rayon, cotton textile, spinning, weaving and finishing, paper and tobacco.

In the rayon industry, the American Bemberg Corp. and American Glanzstoff Corp. are outstanding leaders and their great mills at Elizabethton, Tenn., are served by power plants that have many unusual features. The plant of the American Bemberg Corp. is described in detail elsewhere in this issue. The Glanzstoff plant is about ½ mi. away from it; in some respects the fundamental design of the two plants is the same, although in appearance and equipment they are entirely different. At the Glanzstoff plant, large amounts of process

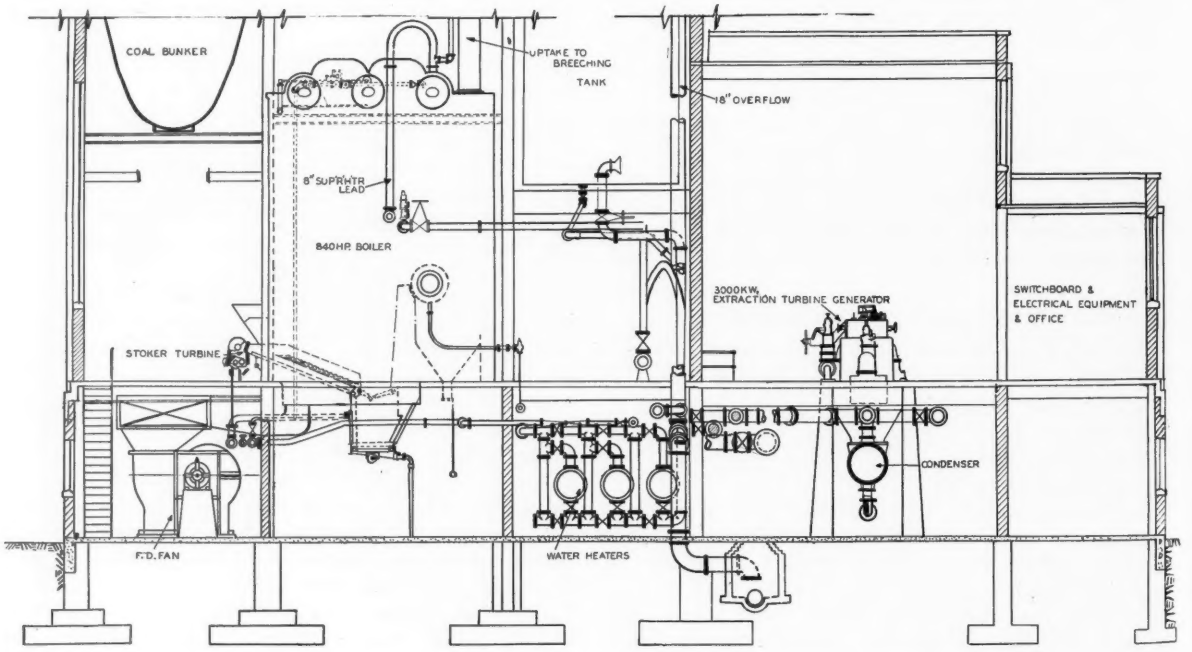


FIG. 1. CROSS-SECTION THROUGH AMERICAN GLANZSTOFF CORP. POWER PLANT

water must be supplied to the mills at various temperatures. This makes it feasible to operate extraction turbines exhausting part of their steam to closed water heaters, heating the process water, which is first passed through the condensers of the turbines and is then heated by the extracted steam. Power generated by the turbines is virtually a by-product and is sufficient to light the mills and operate the machinery. Figure 1 is a cross-section through the Glanzstoff power plant and Figs. 2B and 2C show the principal equipment.

Steam is generated at 250 lb. gage pressure, 150 deg. superheat, by four 840-hp. V-type bent tube, water-tube boilers with convection superheaters. These are fired with 12,500 B.t.u. coal by 8-retort underfeed stokers driven through gears by small steam turbines. Furnaces are of refractory construction with carborundum brick along the slag line inside and a water spray to cool the bridge wall. They are capable of operation at 275 per cent of rating for 4 hr. A motor-driven, 65,000-c.f.m. variable inlet vane control fan and a steam turbine-driven fan, of the same capacity but without vane control, supply forced draft for the stokers. Complete equipment of instruments is provided, while boilers, stokers and fans are under control of a complete combustion control system. Two 350-g.p.m. 5-stage centrifugal pumps, one turbine-driven and one motor-driven, supply feedwater to the boilers.

Two 3000-kw., 3600-r.p.m. extraction turbine generator sets furnish power at 2300 v., 3 phase, 60 cycle. Steam bled from these turbines at 12 lb. gage pressure heats process water in five closed heaters. Circulating water is pumped from a large sand filter plant, about ¼ mi. away on the Wautanga River, to the 2100-sq. ft. condenser of each turbine unit. Passing through these condensers, it flows through the heaters, which are under automatic temperature control to keep the water at constant temperature for the processes.

For heating boiler feedwater in an open 135,000 lb.-per-hr. heater, steam at 12 lb. pressure extracted from the main turbines is available, while the exhaust steam from the small turbines driving feed pumps, stokers, fire pump and other auxiliaries is also used for this purpose and for building heating in the winter. All condensation from heaters, condensers, drips and mill is trapped back to a condensation tank from which it is pumped to the open heater for boiler feed.

Process steam to the mills can be supplied at various pressures from the main header through pressure reducing valves. Air compressors, refrigerating machines and air conditioning equipment are located in the industrial buildings where needed, power being supplied for driving them from several substations located in various parts of the mill.

Electric power is distributed from these substations

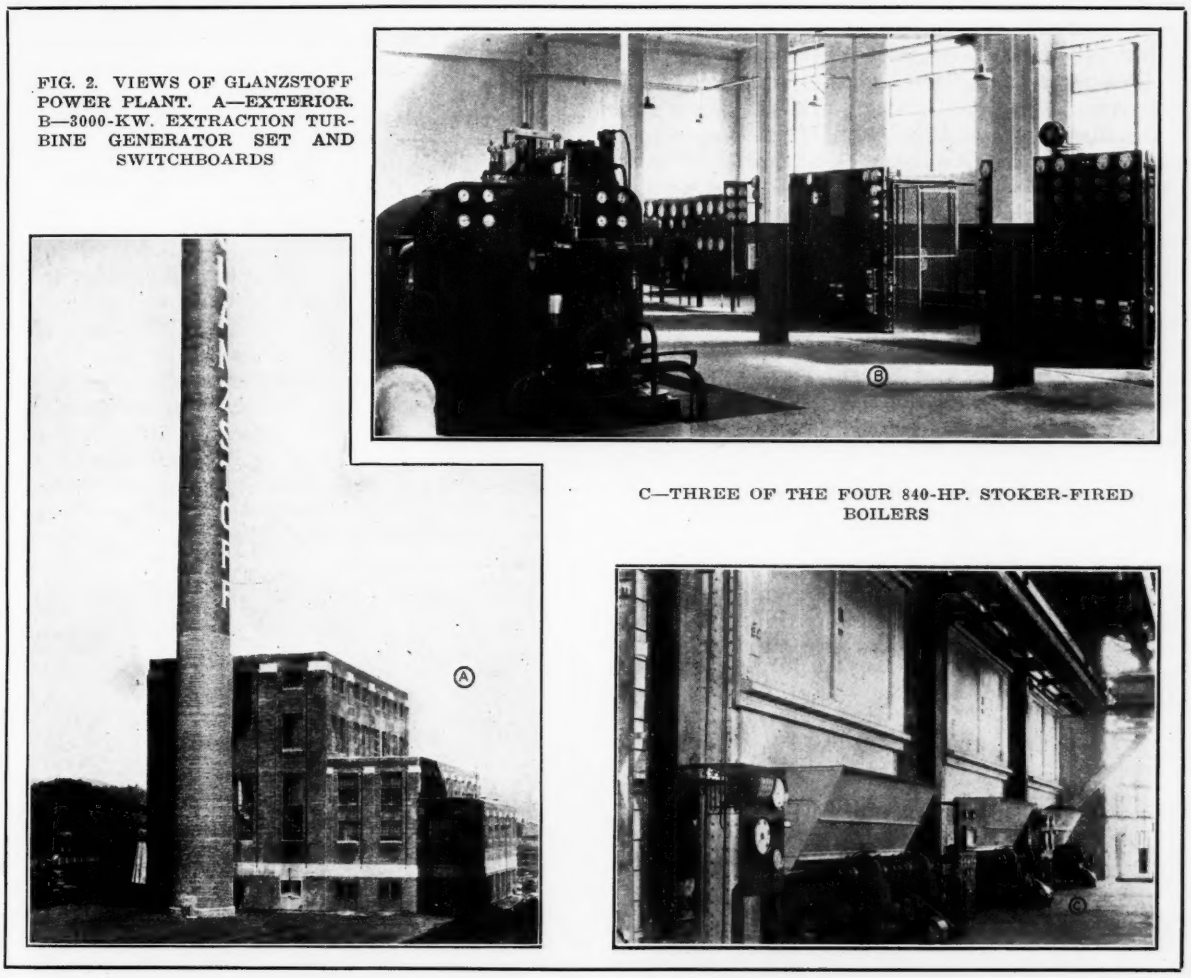


FIG. 2. VIEWS OF GLANZSTOFF POWER PLANT. A—EXTERIOR. B—3000-KW. EXTRACTION TURBINE GENERATOR SET AND SWITCHBOARDS

C—THREE OF THE FOUR 840-HP. STOKER-FIRED BOILERS

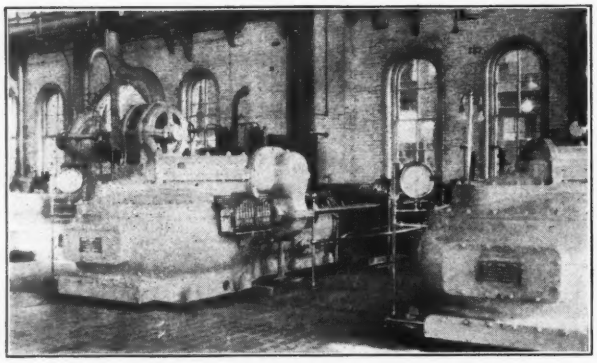


FIG. 3. TWO 20-M.G.D. LOW SERVICE VERTICAL CENTRIFUGALS DRIVEN BY HORIZONTAL UNIFLOW ENGINES AT NASHVILLE PUMPING STATION

at both 2300 v. and 440 v. From one feeder a bank of 2300/440-v. transformers takes power for power station auxiliaries and lighting. A 2300-v. feeder connects with a bank of 2300/440-v. transformers at the American Bemberg Corp. plant to form a tie for emergency service; emergency lighting circuits and essential auxiliaries can be automatically switched over to this tie-line when necessary.

This power plant for American Glanzstoff Corp. was designed by Lockwood Greene & Co. in coöperation with O. Oppenlaender, general manager of the Glanzstoff plant and R. J. H. Worcester, mechanical superintendent for the company. A. A. Wotier is chief power engineer in direct charge of operation.

Nashville Pumping Station

Although the municipal pumping plant at Nashville, Tenn., is not, of course, an industrial plant, a unique feature of this plant seems to be of interest here. This feature is a pair of vertical centrifugal pumps driven by direct-connected poppet-valve horizontal uniflow engines. These are low service pumps, and a new turbine-driven horizontal centrifugal pump, of 20,000,000 gal. a day capacity has recently been installed to do the high service pumping for these units. Besides these units, the station contains a 20,000,000-gal.-per-day vertical triple expansion pumping engine.

Each vertical low-lift pump has a capacity of 20 m.g.d. at 78 ft. head, and is driven at 200 r.p.m. by a horizontal uniflow engine with a steam cylinder of 21 in. bore and 27 in. stroke. These vertical centrifugal pumps were selected because of the excessive rise in river levels, the pumping station floor being 57.5 ft. above normal water level. The pumps are 60 in. in diameter, located at river level and are driven from the engine by a vertical shaft about 53 ft. long. Figure 3 shows the crankcase and horizontal engine cylinder of one of these units. Under test, the two units have shown an average duty of 88,085,000 ft. lb. per million B.t.u. with throttle steam at 160 lb. no superheat and vacuum of 27.4 in. With superheated steam from the new boilers, this performance has been bettered.

These low-lift pumps discharge to a grit chamber which has been incorporated into a filtration plant recently completed. The high service turbine driven unit just completed consists of a 1410-hp., 3600-r.p.m. steam turbine exhausting to a water works condenser and

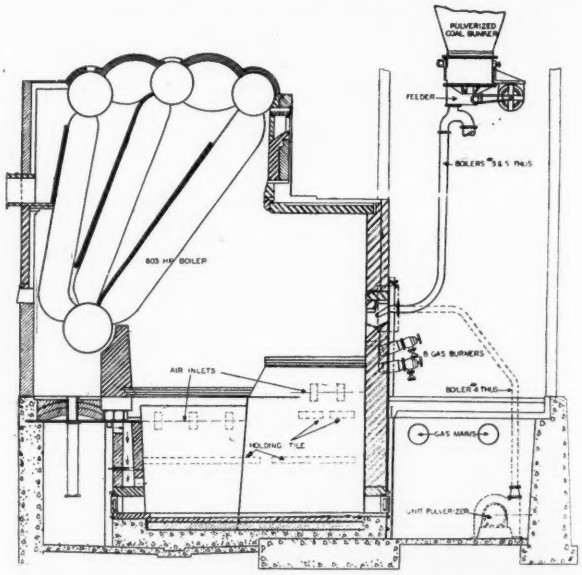


FIG. 5. CROSS-SECTION OF BOILERS 3, 4 AND 5, SLOSS-SHEFFIELD STEEL & IRON CO. BOILERS 3 AND 5 ARE FIRED EITHER BY COKE OVEN GAS OR BY PULVERIZED COAL FROM STORAGE SYSTEM. BOILER 4 HAS SAME ARRANGEMENT OF BURNERS BUT PULVERIZED COAL IS SUPPLIED BY UNIT MILL SHOWN IN DOTTED LINES

driving, through a 3600/820-r.p.m. reduction gear, two 20- m.g.d. horizontal centrifugals in series.

Two 10-m.g.d. turbine-driven high-lift centrifugal pumps and two 12-m.g.d. motor-driven vertical low-lift centrifugal pumps have also been installed, these will be described later.

Steam for these units is supplied by a recently erected boiler house containing three 523-hp. longitudinal drum water tube boilers, making steam at 175 lb. pressure and 200 deg. superheat. These are fired by 5-retort underfeed stokers. Steam turbines drive the forced draft fans, duplex steam pumps supply feedwater and the condensate from these units as well as from the pumping equipment returns to the feedwater heater.

Figure 4 shows the completely equipped and well-lighted machine shop incorporated in this new boiler house. It contains a 42-in. engine lathe, 6-in. lathe, radial post drill, 6-in. pipe threading machine, power hack saw and shaper.

Captain George Reyer is superintendent of waterworks for the city of Nashville, Tenn. with R. L. Law-

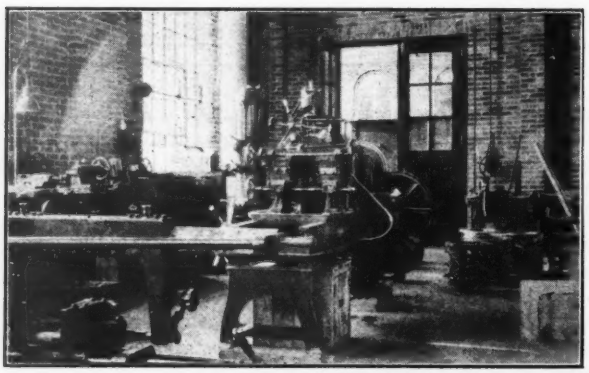


FIG. 4. WELL-EQUIPPED MACHINE SHOP IN NEW BOILER HOUSE, NASHVILLE PUMPING STATION

rence, Jr. as engineer and Sam Underwood as chief engineer of the pumping station. Leonard Metcalf, Geo. W. Fuller and J. N. Chester constituted a board of advisory engineers appointed to survey the water works and recommend certain improvements. After these recommendations were made, the J. N. Chester Engineers were retained by the city to carry them out.

Sloss-Sheffield Steel & Iron Co.

Steel and iron are important products of Alabama, the center of this industry being Birmingham, where the Sloss-Sheffield Steel & Iron Co. is one of the leaders in this field. At one of its by-product coke plants near Birmingham, this company has a large power plant using coke oven gas and coke braise as its principal fuels, supplemented by pulverized coal and generating about 17,000 kw. of electric power, about 1000 kw. of which are used by the by-products plant and about 4000 by a cement plant and quarry, the remainder being transmitted at 44,000 v. to the company's coal and iron mines about 28 mi. away in the mountains. Besides this, a pumping installation with a capacity of about 1,500,000 gal. per day supplies water for the processes.

In the boiler room of the Sloss-Sheffield plant, eight 603-hp. V-type water-tube boilers generate steam at 200 lb. pressure and 150-180 deg. superheat, for use in the turbine room and in the by-products plant. Under these boilers, furnaces of Nos. 1 and 2 burn coke oven gas only, Nos. 3, 4 and 5 burn either coke oven gas or pulverized coal, while Nos. 6, 7 and 8 are fired with coke braise burned on chain grate stokers.

Coke oven gas of about 550 B.t.u. per cu. ft., stored in a regulation gas holder, is sold to the local gas company for distribution to other industries as fuel. Electrostatic precipitators clean this gas, some of which is also burned in the by-product furnaces. Each morning the gas company makes an estimate of the amount

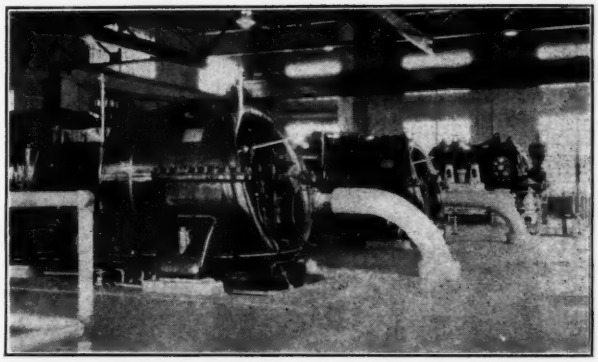


FIG. 7. SLOSS-SHEFFIELD CO. GENERATES ABOUT 17,000 KW. FOR ITS BY-PRODUCTS PLANTS, MINES AND OTHER PROPERTIES

of gas it will need for the day so that the boiler house operators will know approximately how much will be available to them and can adjust their fires accordingly.

Figure 6 shows the first five boilers, the two farthest ones being fired by 8 gas burners each. These two gas-fired boilers usually operate continuously, while Nos. 6, 7 and 8 are operated according to the supply of coke braise. Fluctuations in gas supply or in gas available are taken up by boilers 3, 4 and 5. That is, if the supply of gas increases in the holder above a certain point, pulverized coal burners are shut off and gas burners turned on while if the supply decreases below that point, gas is shut off and coal burned.

Arrangement of the furnaces of boilers 3, 4 and 5 for doing this is shown in Fig. 5. Each of these boilers has 8 gas burners in its front wall with pulverized coal burners above it. Boilers 3 and 5 receive their pulverized coal from a separate coal preparation system in a separate building behind the power house. Here flue-gas dryer reduces initial moisture of 8 per cent to about 1 per cent. A 6-t. mill pulverizes it and a screw

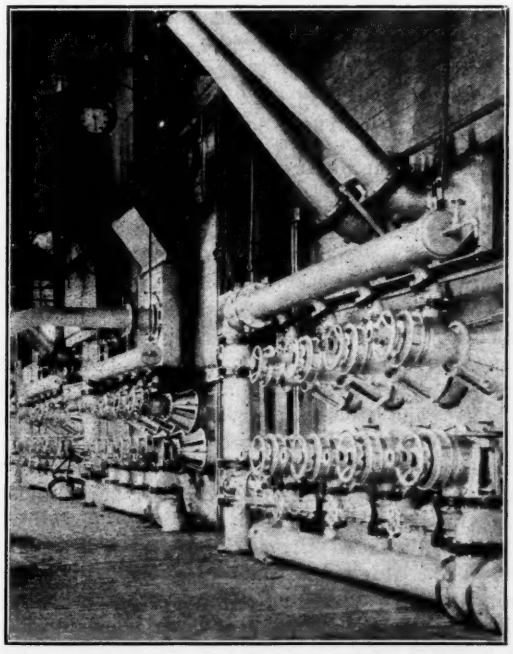


FIG. 6. FRONTS OF BOILERS 3, 4 AND 5, SLOSS-SHEFFIELD STEEL & IRON CO. BOILERS 1 AND 2 IN BACKGROUND FIRED BY GAS ONLY

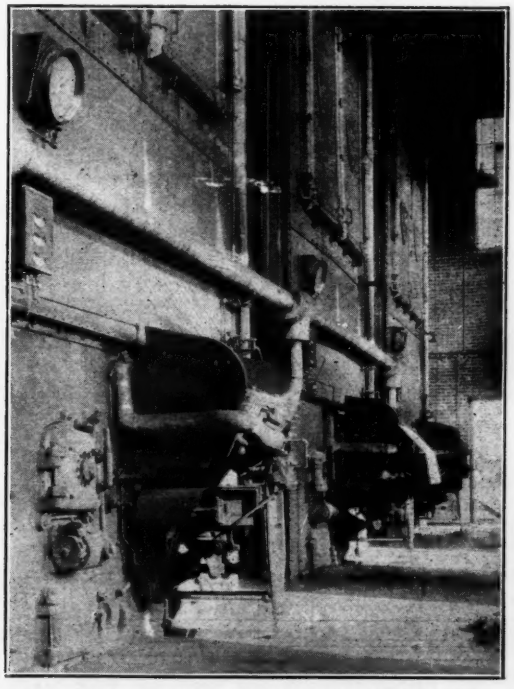


FIG. 8. BOILERS AT NINETY-SIX COTTON MILL

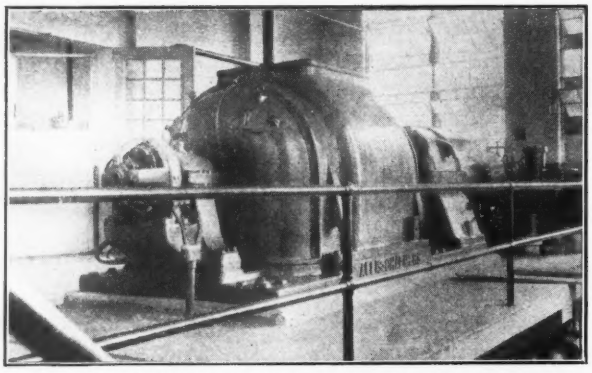


FIG. 9. CONDENSING 2000-KW. TURBINE GENERATOR SET, NINETY-SIX COTTON MILL

pump sends it to the bunkers and feeders over the boilers, whence it is fed to two fish tail burners in each furnace. The entire preparation system is under suction of a fan, which prevents dust and eliminates explosion hazards. Boiler 4 is served with pulverized coal by 5000-lb. per hr. impact pulverizer in the basement feeding to a turbulent burner. Ash is discharged by a sluice.

As shown in the section, Fig. 5, combustion air is heated in hollow rear and side walls of these furnaces. Some of this hot air is introduced to the impact mill for drying and carrying air, while the remainder is supplied to the turbulent burner as secondary air. Two 20,000-c.f.m. fans supply this air. The two gas-fired boilers, Nos. 1 and 2, have Dutch oven furnaces, with air-cooled arches, operating under natural draft.

As can be readily seen, the change from gas to pulverized coal can be quickly made on these boilers as one fuel can be turned on and ignited by the hot furnace before the other is shut off, with no perceptible variation in steam pressure in the process. Controls are all on the firing aisle for this purpose. Full complement of instruments and many refinements in details to procure convenience and economy of operation characterize this plant.

Operation of the power plant is directly in charge of E. P. Winters as power engineer with J. A. Obarr as boiler house foreman. A. F. Elliott is master mechanic for the Sloss-Sheffield Steel & Iron Co. The power plant was designed by the engineers of the company.

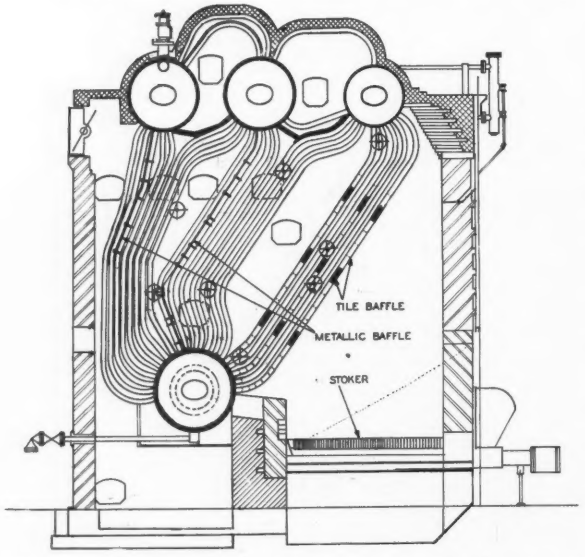


FIG. 10. CROSS-SECTION OF ONE OF THE PAIR OF SINGLE-PASS V-TYPE BOILERS FIRED BY SINGLE-RETORT STOKERS AT PIEDMONT PRINT WORKS

Ninety-Six Cotton Mills

At the Ninety-Six Cotton Mills, Ninety-Six, S. C. is found a power plant that is considered a good example of design for textile mills of this type and has given extremely satisfactory results in operation. The Ninety-

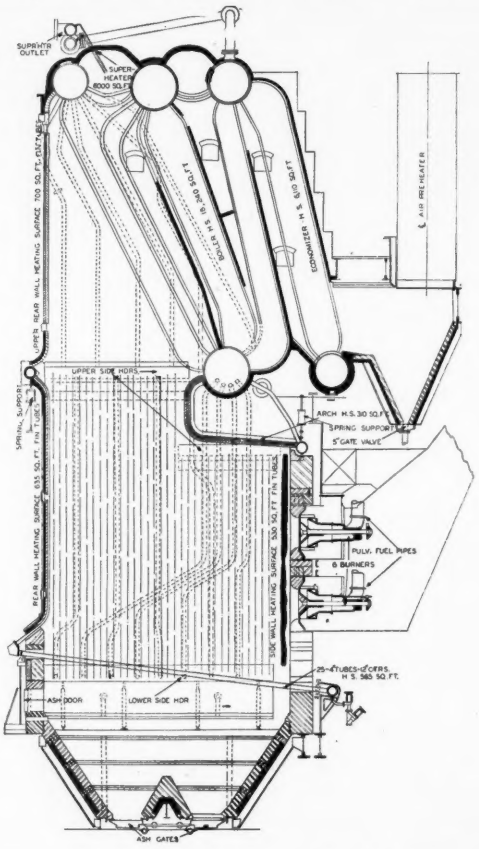


FIG. 11. CROSS-SECTION OF NEW STEAM GENERATING UNIT AT CHAMPION FIBRE CO. IT HAS MAXIMUM CAPACITY OF 300,000 LB. STEAM AN HOUR

Six Mill operates 61,000 spindles and 1400 looms. Power for driving these is generated by a 2000-kw. 3600-r.p.m. turbine-generator set, Fig. 9, with surface condenser spray pond, and the usual auxiliaries. Three 400-hp. water-tube boilers fired by stokers supply steam at 250-lb. pressure, 150 deg. superheat, to the turbine and a small amount through reducing valves to the slashing machinery and the heating system. Coal and ash are handled by hand. This plant was designed by J. E. Sirrine & Co. for the Ninety-Six Cotton Mill of which Jas. C. Self is president, J. G. McNeill, superintendent and J. E. Haas chief engineer.

At the Piedmont Print Works just outside Greenville, S. C., is found an interesting boiler house containing two V-type single pass stoker-fired boilers designed to supply steam to a large print works and finishing mill.

These single pass boilers, Fig. 10, are set in battery and are designed to make saturated steam at 250 lb. gage pressure. Arrangement of the steel and tile

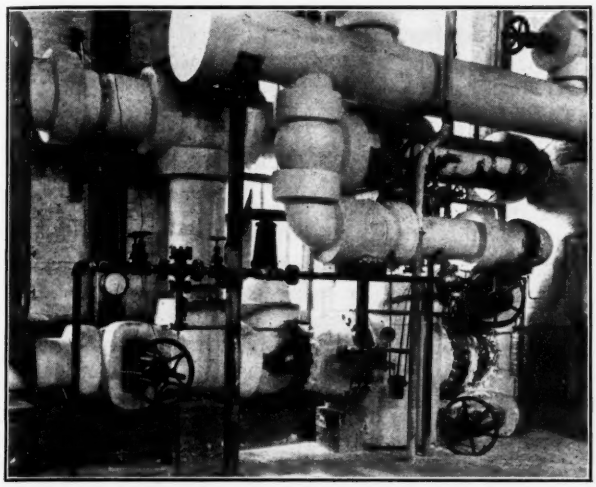


FIG. 12. AT CHAMPION FIBRE CO., NEW 450-LB. STEAM SYSTEM CONNECTS TO EXISTING 175-LB. MILL SYSTEM THROUGH REDUCING VALVE AND DESUPERHEATER

baffling is as shown. Each boiler is fired by a single-retort, steam-driven stoker, coal and ash being handled by hand. Forced draft fan, 3000-hp. deaerating feedwater, heater combustion control system and the necessary auxiliaries and meters complete the plant. Steam is sent to the print works at full boiler pressure through a welded 6-in. pipe line 1000 ft. long on trestles. At the mill, pressure reducing valves reduce the pressure in the first step from 250 to 100 lb. and in the second step from 100 to 40, 10 and 5 lb. A. Boozer is master mechanic of the Piedmont Print Works which is adjacent to and under the same management as the Southern Bleachery.

Champion Fibre Co.

Champion Fibre Co. at Canton, N. C., one of the largest organizations of its kind in the country has recently begun the remodeling of its principal boiler house and has enlarged its turbine room facilities to meet the increased demands of its industrial processes. In the main boiler house at Canton a steam generating unit of 300,000 lb. an hour maximum capacity was installed last year and a duplicate unit is being erected now. It is planned ultimately to have three of these units which will replace 22 old boilers and make large reductions in the operating force. The Champion Fibre Co. manufactures pulp, paper, container board, tannic acid, caustic soda, bindex, turpentine, lime and lumber.

The first new steam generating unit is shown in section in Fig. 11. This consists of a bent tube boiler containing 18,280 sq. ft. of heating surface, a steaming economizer of 6110 sq. ft., and a convection type superheater of 6000 sq. ft. surface designed to make steam at 450 lb. gage pressure, 700 deg. total temperature. While the maximum steam capacity of the unit is 300,000 lb. an hour, it operates normally at about 230,000 lb. an hour.

Furnace of this unit is almost entirely water-cooled with fin tubes on side and rear walls as shown and a plain tube hearth screen at the bottom. It is fired with pulverized coal by six turbulent type burners firing through the back tile wall under the lower boiler drums. Pulverized coal is supplied to these by three motor-driven impact pulverizing mills each with a capacity of 12,000 lb. an hour. Coal is obtained from the company's own Black Diamond Mine. Ash drops through the hearth screen and is discharged through ash gates to a sluice which transports it to a pit in the yard.

Flue gas leaving the boiler is drawn through a 31,360-sq. ft. plate type air preheater by a steam-turbine driven 285,000-c.f.m. (maximum) induced draft fan located over the boiler. Forced draft for primary and secondary is supplied by a 109,000-c.f.m. steam turbine-driven fan, also located above the boiler. The turbines driving these fans are designed so that they can discharge at any one of three pressures, 175 lb., 20 lb. or 2 lb. to the low pressure headers.

The old boilers operated at 175 lb. pressure, steam being furnished at this pressure to the digesters and at 20 lb. to evaporators and paper machine dryers.

The new boilers will supply steam to the 175-lb. lines through a reducing valve and desuperheater; also a new 4000-kw. extraction turbine, Fig. 13, has steam extracted at this pressure and exhausts at 20 lb. to the 20-lb. system. Extracted steam is introduced into the 175-lb. system just ahead of the desuperheater, Fig. 12. Turbines driving fans and boiler feeder pumps on the new unit can be manually controlled to exhaust either to the 175-lb. or 20-lb. system, according to the excess steam available. These small turbines can also exhaust at 2-lb. gage direct to the open feedwater heater. A 3000-kw. mixed pressure turbine-generator set takes throttle steam either at 175 lb. or 20-lb., using any excess 20-lb. steam and exhausting to a jet condenser. To utilize excess amounts of 175-lb. steam, a 1250-kw. turbine unit takes steam at 175-lb. and exhausts to the 20-lb. system. This unit will not be used except as a standby after the second steam generating unit is put in. In summer, when the steam plant is generating about 500,000 lb. an hour, only about 40,000 lb. of it or less than 10 per cent, goes to condensers; in winter, no steam is condensed.

Condensate from evaporators and dryers is returned to the boilers after oil is filtered out. Makeup from the Pigeon River is softened and chemically treated to remove causes of embrittlement and both condensate and makeup are heated in an open feedwater heater.

Many other interesting and unusual engineering details are incorporated in the plant of Champion Fibre Co.; the foregoing discussion, however, is intended to cover only the most important and outstanding characteristics. The new power plant was designed and is operated by the engineering staff of Champion Fibre Co. under the supervision of W. R. Crute, plant engineer.

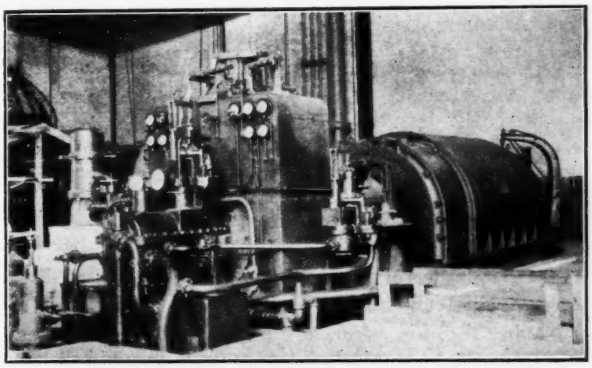


FIG. 13. STEAM IS EXTRACTED AT 175 LB. FOR THE MILL SYSTEMS FROM THIS NEW 4000-KW. EXTRACTION TURBINE GENERATOR SET AT CHAMPION FIBRE CO.

Diesel Engine Lubrication

Qualities That Are Important in Selection of Diesel Lubricant. By R. C. Demary*

FOR SEVERAL years, the author was employed as erector and trouble man by one of the largest manufacturers of Diesel engines in the United States, and in the following discussion gives the results of his experience.

We all know that two metal surfaces rubbing together cause friction and that, to reduce this friction, we must use some kind of lubricant. This lubricant or oil must form a film that will entirely separate the two metal surfaces. We might say that the bearing surface floats on a film of oil.

Characteristics of Good Lubricant

A lubricant must possess, therefore, the following three characteristics: 1. It must be capable of forming a film between two rubbing surfaces, 2. it must have low friction qualities within itself, and 3. it must resist being squeezed from between the bearing surfaces. There are other qualities which a good lubricant should have but the ones mentioned are of the most importance.

Difficulty with lubrication indicates one or more of the following possibilities: 1. The oil may have been poorly refined, 2. it may not be fed to the cylinders in the right amount or at the right time, 3. it may be a good oil but one not adapted for this particular engine, or 4. the lubricating system may have been improperly designed.

Trouble due to the first cause is frequently encountered, although not so often where well known brands of oil are used. The second case depends upon the vigilance of the engineer. In the third case, it may be necessary to change oils and use one better adapted to the engine. Fortunately trouble due to the last mentioned cause, although it still exists, is becoming rare.

Lubrication requirements in the operation of Diesel engines, are much more severe than for steam units. A suitable lubricant for a Diesel engine must have three requirements: 1. It must be able to lubricate the piston in an efficient manner at a fairly high temperature. 2. It must seal the piston rings to prevent leakage. 3. It must burn without forming too much carbon in the cylinders.

Cylinder Temperatures

The first requirement is important and depends upon the viscosity of the lubricant. The higher the viscosity the less fluid the oil and this property decreases greatly as the temperature is increased. Viscosity is generally denoted as light, medium or heavy but may vary greatly with two light oils of different brands. Thus we find that the higher the viscosity the thicker the oil but we must not lose sight of the fact that all oils decrease greatly in viscosity with a slight increase in temperature.

Many engineers declare that they are using the best of oils, yet have lubrication trouble and always will have in a Diesel engine because of the extremely high temperatures in the cylinders. Let us see just what these extremely high temperatures are. Experiments have shown that a maximum temperature of about 2675 deg. F. obtains at the beginning of the power stroke or upon ignition of the fuel charge. This temperature decreases as expansion of the burning charge and exhaust take place. It gradually rises during the compression stroke. The minimum temperature is about 250 deg. F., with an average during the complete cycle of approximately 945 deg. F. These are temperatures of the gases and not those of the cylinder walls. The point to emphasize is the great difference between the temperature of the gases and the cylinder walls, since this has an important bearing on cylinder lubrication.

From a series of experiments conducted by Prof. W. B. Meriam, it was found that the cylinder walls had a temperature of only about 30 deg. F. above the temperature of the circulating water, therefore, as long as the water is not boiling, we know that the temperature of the cylinder walls is not higher than 250 deg. F. in a Diesel engine and the temperature of the pistons is only a few degrees above the temperature of the cylinders. Therefore the high temperatures need cause us no great concern.

Effect of Heat on Oils

Action of oils when heated is determined by the flash point and the fire point. The flash point is the temperature to which the oil must be heated in order that the vapor given off will make a slight explosion when a flame is held directly over the oil. The fire point is the temperature to which the oil must be heated in order that it will ignite and burn continuously, after a flame has been applied to it. The fire point is usually from 40 deg. to 50 deg. F. above the flash point. Practically every oil used in lubricating Diesel engines has a flash point above 320 deg. F. and, if the temperature rises above that point, something must be wrong, not with the oil but with the operation of the engine. Such trouble should be located and corrected but this cannot be done by feeding more oil or by change of lubricant.

Lubricating oil does not burn readily and furthermore the time allowed in the cylinder is short. An engine running at only 100 r.p.m. would expose the lubricated surface of the cylinder to the action of the flame for less than one-quarter of a second. At higher speeds, the time allowed for the oil to burn is so short that a flash point of 300 deg. F. would be sufficiently high for any Diesel engine except under the most unusual conditions.

Carbon Deposit Is Chief Trouble Maker

In connection with the operation of Diesel engines the chief trouble maker is carbon deposit in the cylinders. The lubricating oil is, of course, blamed for this and at times the blame may not be unwarranted but in

*Combustion Engineer, City of Akron, Ohio.

most cases the operator is at fault and a little more care and thought on his part would eliminate shutdowns from carbon trouble. Carbon exists in two forms: first, fine carbon suspended in the fuel and lubricating oils; second in chemical combinations forming hydrocarbons which go to make up the oil. The amount of fine, free carbon is small and the trouble from that source should hardly be considered.

Methods of Reducing Carbon Trouble

With the fuel so regulated as to give a clear exhaust and by using only sufficient oil to lubricate the cylinders, carbon troubles will be reduced to a minimum. In nearly every case on which I have been consulted, I found the engineer using much more oil than was necessary for proper lubrication. An overlubricated cylinder will always cause trouble from carbon. During my experience, I found that the addition of a small amount of graphite, about two tablespoonfuls to one gallon of oil, would aid greatly in lubricating Diesel cylinders and in its use a marked decrease in the amount of carbon deposit was noticed. Carbon formed was also easily removed. The necessary quantity of oil depends upon the engine and conditions under which it is operated so that it is necessary to solve this problem for each individual plant.

Selection of the kind of oil best adapted for Diesel lubrication has formed the basis for many heated discussions. Some engineers will use only eastern crudes with a paraffine base, while others prefer western oils having an asphalt base. I have tried both kinds under nearly every condition and from actual experience I have found that oils having an asphalt base give better satisfaction. The claim that these latter oils form more carbon than do oils with a paraffine base I have found to be untrue. Carbon formed from asphalt base oils is also of a softer texture and much easier to remove.

Oils having a paraffine base, such as the Pennsylvania crudes, have, as a rule, a much lower viscosity and to compensate for this it is necessary to resort to compounding. The light oils are mixed with heavier cylinder oil and this latter is responsible for most of the gumming and carbon troubles experienced. The asphalt base oils are composed chiefly of the ethylene and the napthene chemical series and distill without decomposition.

Color of an oil has no relation to its lubricating value. You can, however, tell when the oil is compounded with cylinder stock by the greenish tinge given it by the latter.

Efficient Lubricant Feeders

To secure proper cylinder lubrication, the oil must be applied at just the right time and many lubricators are on the market that are especially adapted for this service. Lubricators should be driven from a lay shaft and so timed that the piston of the lubricator pump works in synchronism with the piston of the engine. The oil should be delivered directly onto the piston, between the rings and at the end of the stroke. Now if we stop to consider a moment, we shall see how important such a method is. The oil that does not strike the piston or is forced into the cylinder when the oil hole is uncovered by the piston is wasted and results in just so much more carbon-forming material. Where a lubricator of the type mentioned is used, the amount of oil fed may be materially reduced. If, on removing a cylinder head or withdrawing a piston, a film of oil of sufficient thickness to penetrate two thicknesses of cigarette paper is found, you are getting a sufficient amount of oil.

In some cases, lubricators are divided into two compartments so that one grade of oil can be used on the cylinders and another on the other bearings. This has been the cause of much trouble because of mistakes made by operators in interchanging the two oils. Furthermore the small saving in the cost of oil does not warrant employment of this method. Do not try to save on oil at the expense of the engine, yet keep in mind that too much oil may likewise cause trouble.

Correct Viscosity

In buying oils, be sure they contain no animal fats. Under ordinary conditions an oil having a viscosity of not less than 200 at 100 deg. F., and a low cold test, is found to give the best results. Sometimes, however, operating conditions are severe and the rings may leak. Under these conditions, an oil with a viscosity of 450 or 500 may be necessary.

Neither oil color nor density signify as specific properties in the selection of a lubricant, for, when we mention light, heavy or medium, we are concerned only as to viscosity. Light means low viscosity and heavy means high viscosity. Excessive friction may result from use of an oil of either too high or too low viscosity. Too high a viscosity will give a good oil film but the friction in the oil itself will be excessive. If the viscosity is too low, the film may be broken.

All lubricating oils should be filtered before use and then the oil used should be as thin as possible to retain a perfect film. If this procedure is followed, you will practically solve your lubrication problem, and go a long way toward eliminating carbon deposits.

Michigan's quota of the coal output of the country in 1928 was 617,342 net tons, according to the United States Bureau of Mines, Department of Commerce. Compared with the production of the previous year, this is a decrease of 18.4 per cent and is the smallest tonnage accounted for by the State since the turn of the century. Although not ranked as one of the larger coal mining states, Michigan is a regular producer of bituminous coal, the bureau points out. The coal-mining industry of the state has in recent years experienced the same conditions that have held down bituminous production in the country generally. Total value of the coal produced last year amounted to $2,631,000, or an average value of $4.26 per ton, which was slightly less than that of 1927 when the average value was given as $4.31 per ton. In 1928, there were 1239 men engaged in the industry, of which 1119 were employed underground and 120 on the surface. The total number of workers employed in coal mining the year before was 1512. The average number of days worked in 1928 was 187 as against 188 days in 1927.

Storage does not materially affect the quality of most coals.

Boiler Testing by the Heat Balance Method

WHERE IT IS IMPOSSIBLE OR IMPRACTICAL TO MEASURE THE COAL AND WATER USED BY A BOILER, THE UNIT MAY BE TESTED BY THE HEAT BALANCE METHOD QUITE ACCURATELY. BY B. J. CROSS*

IF IT IS IMPOSSIBLE to weigh the water evaporated, the only alternative for the purpose of determining the efficiency of a steam generating unit is the heat balance method which consists of the measurement of the losses and subtraction of their sum from 100 per cent; it is perhaps more accurately called the method of losses. The heat balance is a part of all complete evaporative tests where fuel and water are weighed. Heat absorbed as determined by the weight of water evaporated and its increase in heat content plus the sum of all the losses should equal 100 per cent.

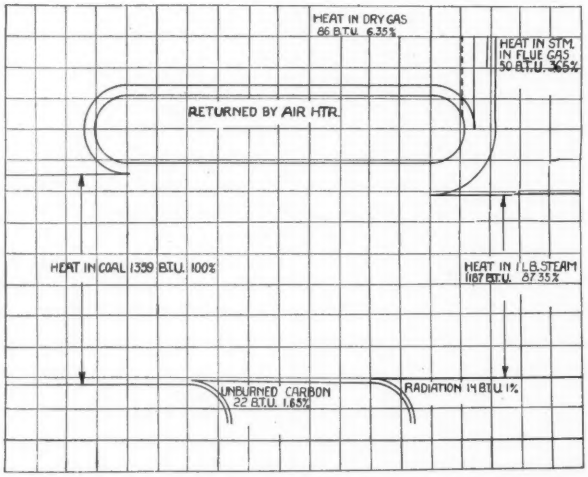


FIG. 1. HEAT FLOW DIAGRAM OF A STEAM GENERATING UNIT

While not all of the losses can be measured, those that can be measured can be determined quite accurately, while those that can not be readily measured are small and are of the order of less than a tenth of a per cent. The item, "unaccounted-for losses" in the heat balance, therefore, consists almost entirely of errors which are commonly considered to lie in the measured losses. Losses that can be measured are as follows:

1. The loss due to the sensible heat above room temperature in the dry flue gases.
2. The loss due to steam in the flue gases. This steam comes from three sources; from evaporation of the moisture in the fuel; from water formed when the hydrogen of the fuel combines with oxygen; and from the water vapor present in the air used for combustion.
3. The loss due to incomplete combustion of carbon. This loss is evidenced by the presence of carbon monoxide in the flue gases.
4. The loss due to unburned solid carbon. This loss is represented by the carbon or combustible in the refuse from the ash pit and various settling chambers and the carbon in the refuse that is carried up the stack with the gases.
5. The loss due to the heat radiated from the surfaces of the unit. This loss can not be directly measured but can be estimated and a figure set as a high limit.

*Combustion Engineering Corp., New York. From a paper presented before the Metropolitan Section of the A. S. M. E.

Figure 1 shows a heat flow diagram of a steam generating unit with the quantities to scale so as to show the relative magnitude of the various quantities. The individual losses are small compared to the heat absorbed and a comparatively large error in their determination will have a proportionally small effect on the efficiency.

THE DRY GAS LOSS

Loss due to heat in the dry flue gases is the largest item of the heat balance and is susceptible to the largest error so that the greatest precautions should be used in its determination. The most important measurements in the determination of the dry gas loss are the CO_2 and flue gas temperature. The oxygen and CO are small quantities and considerable error in their determination causes only a small error in the result. C_b, the carbon burned will vary only slightly with an error in the unconsumed carbon. It is improbable that any considerable error will be made in room air temperature.

The possible error in measuring CO_2 is influenced almost entirely by the location of the sampler. Once the sample is in the orsat, its analysis can be made with an accuracy of plus or minus 0.2 of a per cent. The difficulty lies in obtaining a true sample. Many devices have been tried in the attempt to obtain a single sample that is representative of the composition of the gas. Probably the best way is to use simple open end pipes, taking as many samples in as many locations as the resources at hand permit. In wide settings, as many as six samplers distributed across the setting may be necessary. A preliminary traverse of the breeching may be made and the variation in composition of the gases determined. The greater the variation the larger the number of sampling points will be necessary. In modern units where often both economizers and air heaters are employed, the gases are apt to be rather thoroughly mixed by the time they leave the system and the sampling thereby simplified. Air leakage between the various units increases the difficulty of sampling and should be kept at a minimum. The error in the per cent CO_2 due to sampling and analysis should with proper care not exceed half of a per cent.

TEMPERATURE MEASUREMENT

As in the sampling and analysis of gases, the possible error in the determination of temperature of the flue gases is due almost entirely to the location of the instrument used. The solution similarly is to use as many points as possible. A temperature traverse may be made and the number of points to be used and their locations thus determined. The use of thermocouples in this measurement permits a large number of temperature measurements to be made in a section of the breeching with a minimum of effort and expense. In a breeching for example, of 5 by 15 ft., five couples may be located at 3 ft. intervals. Each couple may then be moved to five positions. Twenty-five readings

can thus be made at as many points in the section. If a little care has been taken in wiring the couples to a convenient switch, these 25 measurements can be made in not more than five minutes. A potentiometer should preferably be used in measurements as there is then no error due to the resistance of the leads.

The calibration error of a couple over the range of temperatures found in flue gases should not exceed 2 or 3 deg. The largest chance for error is due to the location of the couple and the radiation of heat to cooler surrounding surfaces. In ducts, the walls of which are well insulated, the temperature of the walls will not be far below that of the gases. The error due to radiation should not exceed 10 deg. F. The combined error due to radiation and location should not exceed 15 deg. F.

Figure 2 shows the loss due to heat in the dry flue gases at various temperatures plotted against CO_2. Thus at 15 per cent CO_2 and 500 deg. temperature, an error of ½ per cent in CO_2 and 15 deg. in temperature will cause an error of 85 B.t.u. or 6 per cent of the total quantity of heat lost. But this represents an error of only 0.5 per cent in the efficiency. At a temperature of 300 deg. and 15 per cent CO_2, the same errors in measurement will cause an error of 65 B.t.u., or 9 per cent of the total loss. But again this represents an error of only 0.55 per cent in the efficiency.

Steam in Flue Gas

Second in importance in size is the loss due to moisture in the flue gases. This moisture comes from three sources, the moisture in the fuel, the water vapor present in the air used for combustion, and the moisture formed by the combustion of hydrogen in the fuel.

Loss Due to Unburned Carbon

Loss due to unburned carbon is difficult to measure. If this loss occurred entirely in the ash pit, its determination while it might be rather laborious, would be comparatively simple. A large part of the unburned carbon, however, passes out of the stack with the gases. This is true both of stokers and powdered coal fired furnaces. The ash pit loss can be determined by the weight of refuse and its analysis. The loss of carbon in the stack gases can be determined with a fair degree of accuracy by aspirating a known weight of gases through a collector and filter. The combined error of sampling in quantity of refuse and quality of the sample obtained should not exceed 20 per cent.

The Radiation Loss

Loss due to radiation of heat from the boiler setting can not be directly measured. The rate of radiation from such surfaces has, however, been the subject of much study and is of the order of about 250 B.t.u. per hr. per sq. ft. Boiler and furnace walls are usually well insulated and there are few parts of a setting where the hand can not be comfortably held. The actual loss due to radiation is practically constant regardless of rating. It can be estimated for normal rating of the boiler and the loss at any rating may then be computed by dividing by the per cent rating. The per cent loss due to radiation will thus vary considerably with rating. At moderate ratings, it will be in the neighborhood of 1.0 per cent. The error in computing this loss will not exceed 25 per cent of the loss and would cause an error of 0.25 per cent in efficiency.

Sampling and Analysis of Fuel

Error in the heat value of the fuel may result from two causes: the sampling of the coal at the plant and in the analysis of the sample in the laboratory. For the purpose of a heat balance test an error of 200 B.t.u. in the heat value of the fuel, fortunately is not serious.

As the amount of CO is small—usually it is unmeasurable—and the same per cent error in its determination applies as for CO_2 determination, the error in the determination of this loss can be safely neglected.

Unaccounted-for Losses

If radiation has been accounted for by the method previously described, the unaccounted-for losses should

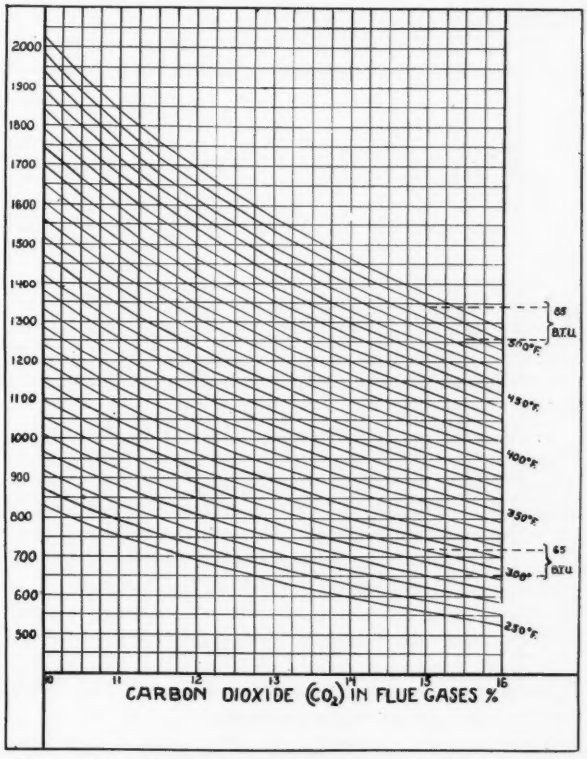


FIG. 2. HEAT LOSS IN DRY FLUE GAS AT VARIOUS TEMPERATURES PLOTTED AGAINST CO_2

consist only of the undetermined items of the gas analysis and sensible heat in refuse. The undetermined constituents of the stable gases consist of unburned hydrogen and hydrocarbons. The loss due to these constituents can almost invariably be neglected because they usually exist only in traces.

The amount of heat lost due to the sensible heat in the ash and refuse is usually very small, although if ashes are rejected from the furnace in molten state the loss may be appreciable; however, in this special case the loss may be readily calculated.

The possible errors of the items of the heat balance as discussed in the preceding paragraphs are to be considered as the maximum errors when all reasonable precautions have been taken to obtain accurate measurements of the factors involved. These errors are for the

greater part accidental rather than constant. They may be plus or minus in direction and just as apt to be compensating as additive. Considered under the most unfavorable circumstances where they will be additive, the total error in the sum of the losses will be the sum of the errors of the individual losses. The total maximum error in obtaining the efficiency of a boiler and furnace by the heat balance method may be determined therefore by summing up the individual errors. Thus the total error of a carefully made heat balance efficiency test will be as follows:

1.	Error in dry gas loss	0.5 per cent
2.	Error in loss from steam in flue gases	0.1 per cent
3.	Error in loss in incomplete combustion	0.4 per cent
4.	Error in radiation loss	0.2 per cent
5.	Error due to sampling and analysis of fuel	0.2 per cent
	Total error in efficiency	1.4 per cent

If we add 0.1 per cent for the unmeasured losses, the total possible error in efficiency will be 1.5 per cent.

To those who like to report the results of a boiler test to the second decimal place, the admission of a possible error of 1.5 to 2 per cent in a heat balance test would seem to condemn such a test; however, if we investigate the possibility of errors in a weighed coal and water test, we will find that even though all measurements are made with great care, the probable error of such a test will not be greatly different from that of the heat balance test. Unlike the efficiency as determined from the heat balance, the efficiency is determined from a weighed coal and water test is greatly affected by an error in the heat value of the fuel. An error of 150 B.t.u. in the heat value will cause an error in efficiency of over 1 per cent.

A comparison between the efficiency as obtained from weighed water and coal and efficiency as determined by heat balance shows the maximum error or difference to be about 3 per cent. As the maximum probable error of both the heat balance test and weighed water and coal test is in the neighborhood of 1½ per cent, a combined error of 3 per cent is possible.

Principles Involved in Locating Drain Pipes

Drop in Steam Pressure in Transmission Piping Due to Presence of Condensate Warrants Investigation of Drip Pipe Locations. By J. W. Brassington

PASSAGE of steam through a pipe involves the carrying and depositing of the entrained water, therefore it is a peculiarly puzzling subject because of the combination of two elements in the one system each being affected by different laws.

It is possible to measure the difference in pressure between the ends of a pipe, to determine by meters the quantity of steam delivered over a given period, to measure the quantity of discharge water at drip points and determine the velocity of flow distribution by pitot tubes. We have also the knowledge that the following factors are always present: friction due to interior surfaces and capillary action, inertia of both the steam and the entrained water and the force of gravity.

Influence of Capillary Attraction on Flow of Condensate

Presuming that the steam is saturated, that is, at the dew point, on entrance, we know that loss of temperature means condensation. The condensate, being heavier than the steam, will be kept in motion along the pipe only by friction with the steam or the action of gravity. If this water were perfectly free from all pipe contact, its speed would be controlled by the speed of the steam only but, owing to its adhesion to the walls of the pipe because of capillary attraction and gravity, its movement is proportionally retarded.

The common assumption that the flow of condensate in steam pipes is only along the bottom of the pipes is an error. A visual study of the actual conditions in a glass tube conveying wet steam shows that the condensate is propelled along the entire interior surface of the tube. A certain quantity is carried along in the center of the current of steam but the outside layer of traveling steam deposits a film of moving water all over the inside of the pipe. The effect of gravity on this film being sensibly less than that of capillary attraction, in the case of excessive condensation, when the walls of the pipe are covered with enough water to satisfy the capillary attraction, then the excess water begins to show itself at the bottom of the pipe.

Weight of Condensate May Equal that of Steam in Pipe

When the difference in density of steam and water is taken into consideration, a proportion of about 1 to 1700, it is evident that the weight of the thin film on the interior of a pipe may well be equal to the weight of the contained steam at any given moment. The usual method of draining pipes, especially large ones, from their lowest level is only partially correct and a method far more efficient is to arrange for an enlargement of the pipe at points of drainage, so enabling the water around the interior surface of the pipe to find an exit and escape from the drift of the steam. The most thorough removal of condensate possible should be aimed at. When it is remembered that it is nothing unusual for the steam direct from the boiler to carry 5 per cent or more of entrained moisture, it is evident that a steam separator should be installed in the main header before it leaves the boiler room.

Locating the Steam Separator

Steam separator design always embodies the principle of enlarging the diameter of the pipe so as to trap all the water on the interior surface. A separator, however, is always much larger in diameter than is necessary for this purpose alone because it must include a device in the center of the current to separate the entrained water which is otherwise carried along without ever getting a chance to hug the walls. The main steam header from the boilers should incline slightly upwards

to the separator so that the excess moisture will return by gravity to the boiler. It is good practice to run a drip header directly under the main steam header with bleeder valves directly under the connection from each boiler to the main header and at every point in the line such as a valve, an expansion joint, an expansion bend or any place where the continuity of the interior surface of the line is interrupted.

Delivery of practically dry steam from the boiler room is of prime importance. If the steam header in the boiler house has a double end delivery, arrangements should be made so that steam to the engine room can be obtained from each end and each end should have at least one big separator in the line although two in series are preferable. In the case of a one end delivery boiler header, a bypass should be in place to allow for repairs to separators. The writer recommends that two separators in series be placed on each pipe. Separators are invariably placed on the steam lines to prime movers but moisture in steam seems almost inevitable except where superheated steam is used.

Draining Long Steam Pipe Lines

In the steam headers feeding portions of the plant outside of the main engine room, it is usual to find that the force of gravity is the sole power used for the removal of entrained water and free condensate. Unless the steam is to be used directly in an outlying steam engine, which is nearly always supplied with a separator, no attention is paid to the advisability of removing the entrained moisture or the moisture carried on the walls of the piping by capillary attraction. As a general rule, only the free condensate is removed by means of drip pipes and traps about every 100 ft. of pipe line. This method usually affords ample protection against the dangers of water hammer.

In determining in a systematic way, the location and number of drain points on any outside line of steam piping, sufficient information should be obtained to indicate closely the load or flow of steam, the drop in pressure, the approximate condensation and the suitability of the pipe in question in respect to size, condition and insulation. This can be done by means of steam meters, pressure gages and calorimeters. An excerpt from a standard table of flow of steam in pipes, giving the steam pressure, diameter and length of pipe and weight of steam transmitted per pound drop in pressure, such as can be found in any good mechanical engineer's handbook, is of value in checking up conditions.

Pressure Loss Reduced from 40 to 5 lb.

In one instance known to the writer, an 8-in. well covered pipe supplied steam to engines of 250 hp. total capacity, a big cooking apparatus and several auxiliaries such as fans, pumps and presses. Drip pipes had been installed every 100 ft. of the half mile or so of pipe. The estimated amount of steam required per minute, based on usual practice, was 1300 lb.; the drop in pressure over the line was 40 lb.; the capacity of the pipe for a drop of 40 lb. should be, according to estimate, 1600 lb.; while the orifice meter test at the inlet end of the pipe indicated a flow of 1560 lb. per min.

That particular pipe was replaced by a 10-in. pipe well covered and the pressure drop was reduced to something like 5 lb. Before the change was made, as there was an interval between the time of the first test and the time the steam was turned into the new 10-in. pipe, the 15 drips on the line were helped out by tapping ⅜-in. drip pipes into the flange connections at an angle so that the inside of the tap hole just missed the inside of the narrow copper gasket inside the bolt circle. These extra drips ran full all the time. We put them in every third flange and cut the drop of pressure nearly 10 lb. All this gain was not due entirely to the new drips because some leaks were also stopped. The leaks were stopped first and the taps were also in place when the writer next visited the plant; the amount of drop in pressure saved due only to the new drips is not recorded.

Experiences of this sort lead the writer to believe that it pays to put a multiplicity of drips into any steam line, piping the drips together by a drip header to a trap. The drip should be placed where the continuity of the inside surface of the steam header is interrupted either by a fitting, flange, valve or what not.

If an opportunity should ever arise within the control of a reader to carry out an experiment demonstrating the great difference in efficiency of drips due to location, as indicated, it is hoped that facts will be given out for publication. It is evident that the drip in between points where the continuity of the inside surface of a header is broken is superior to a drip not so located; every pipe fitter knows this; but may it not be advisable to specify an enlargement fitting every 50 ft. on any steam line for drip purposes as a standard item in steam pipe specifications?

United States Produces Small Proportion of World Output of Fuel Briquets

Because of its abundant supplies of high-grade coal, the United States contributes but a small part of the world output of fuel briquets, says the United States Bureau of Mines, Department of Commerce, in a report just issued. The coal briquetting industry has attained its greatest development in countries where a large part of the available coal is of low-grade and is unsuitable for use in its raw state, it is pointed out. In round numbers the total world production of fuel briquets is now about 52,000,000 metric tons, of which Germany contributes about 87 per cent. France and Belgium are the second and third largest producers and their combined output is about one-seventh of the German tonnage. The quantity of briquets produced in Netherlands and Spain most closely approximates the output of plants in the United States.

In Germany the production of lignite briquets has increased 36.6 per cent during the past five years. In 1928, when the production of German lignite was 166,224,159 metric tons, approximately 79,500,000 metric tons were briquetted, and the output of lignite briquets was 40,158,478 metric tons.

Further details are given in the Bureau of Mines report entitled Fuel Briquets in 1928, by O. E. Kiessling and J. M. Corse, which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a price of 5 cents.

Electricity---What It Is and How It Acts*

PART XXVIII. THE NATURE OF LIGHT. INTERFERENCE AND DIFFRACTION. PLANCK'S THEORIES. BY A. W. KRAMER

SO FAR IN our discussion of radiation phenomena, we have considered mainly the action of the electron and have somewhat carelessly permitted the pulse of radiation produced by the falling electron to escape out into space. Where has it gone? What becomes of this wave? If it is true that this pulse of radiation represents the energy due to the "falling in" of an electron, what becomes of this energy?

Before we attempt to answer these questions, let us investigate somewhat further the nature of the radiation itself. What is light? In many ways, light seems to be a wave in an elastic medium, just as sound is a wave

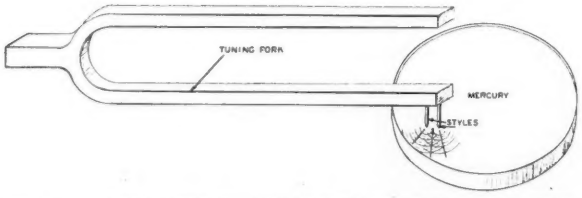


FIG. 1. TUNING FORK ARRANGED TO SEND OUT TWO WAVE TRAINS

By attaching two styles to one prong of a tuning fork and arranging the fork so that the points of the styles just dip into the surface of a bowl of mercury two series of waves will be emitted, one from each style. As these waves expand in ever widening circles they will interfere with each other giving the effect shown in Fig. 2.

in air. Such elastic waves move with a speed which is the same for all wave lengths. For sound in air at 0 deg. C. this speed is 1188 ft. per second. For light in vacuum it is 186,000 miles per second. Sound waves and light waves spread out from the source uniformly in spherical ripples, the intensity diminishing as the distance from the source increases. The phenomenon is similar to the spreading of the ripples in water when a pebble is dropped into a pond.

DIFFICULTY IN CONCEIVING LIGHT AS A WAVE

There is one great difficulty, however, in conceiving light as a wave and that is the absence of any recognizable medium in which the wave is produced. Water, we can see—not only the water but the wave in the water itself. Waves in the air, although we cannot see the air, can be heard; sometimes as in the case of an explosive wave, they can be felt. The air, we know, exists because it can be compressed and analyzed—it even can be liquefied. In the case of light, however, there is nothing, except the effect of the radiation on our sense organs or upon chemical or electrical devices. There is no medium that we can discover in which the light wave travels, yet all the evidence until within recent years seemed to indicate that light is a wave.

So the ether was invented. The ether was supposed to be an imponderable, structureless medium pervading all space and all matter by means of which light waves were transmitted. The supposition of the existence of such a medium, while in many ways unjustified, was necessary because the mechanics of light propagation through space demanded it. The assumption of an ether was merely an easy way out of what seemed an insuperable difficulty.

While light shows characteristics of being a wave motion in a number of ways, the crucial test for the existence of waves of any kind is that of interference

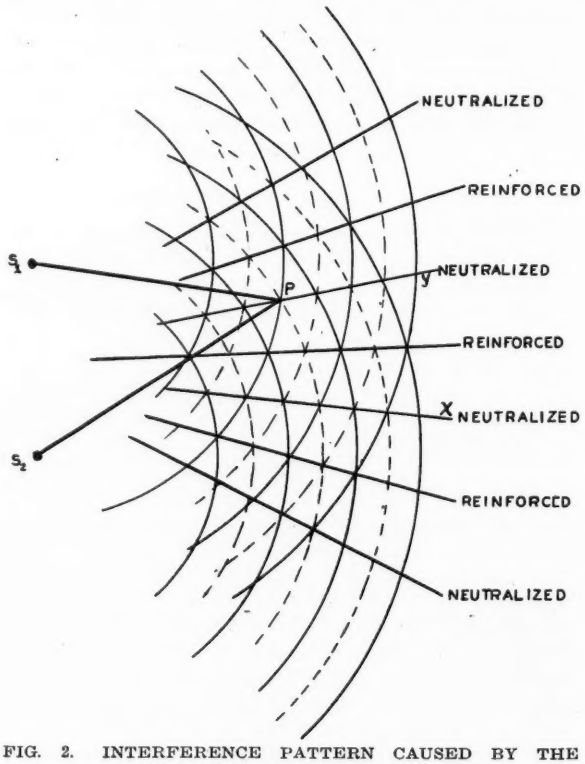


FIG. 2. INTERFERENCE PATTERN CAUSED BY THE APPARATUS SHOWN IN FIG. 1

S_1 and S_2 are the two sources of similar waves. The crests (full circles) meet the troughs (dotted circles) at various points and the locus of each series of these points is the line along which there is interference and nullification.

and diffraction. Interference is the phenomenon obtained when two wave trains having the same wave length and moving in the same direction are superimposed. Nearly all of us at one time or another have amused ourselves by tossing pebbles into a pond and watching the ripples spread out in ever-widening circles. Perhaps, at times, two pebbles fell in the water at once. When this occurred, in some places the crests of two sets of ripples would come together and reinforce each other. At other points the crests of one set of ripples would fall on the hollows of the other and both would be neutralized.

Interference of sound waves can be demonstrated by attaching two styles to an electrically operated tuning fork and arranging them so as to dip into a bowl of mercury as shown in Fig. 1. When the fork vibrates a series of waves is sent out from each style. If S_1 and

*All rights reserved.

S_2 in Fig. 2 are the two styles, the crests (full circles) meet the troughs (dotted circles) at various points, causing the waves to be neutralized along certain paths and reinforced along certain other paths as shown.

In the same way, two wave trains of light may interfere with each other, so as to cause a succession of light and dark bands to appear. The light bands are the places where the crests of the two groups of waves coincide while the dark bands indicate the coincidence of the troughs or hollows.

Suppose, instead of throwing stones into the water to create interfering waves, we place in the water a grid composed of a number of equally spaced vertical bars. A single wave train directed against this grid will be broken up by the bars of the grid. After passing through the openings, the crests of the emerging waves will recombine to form a new wave going straight

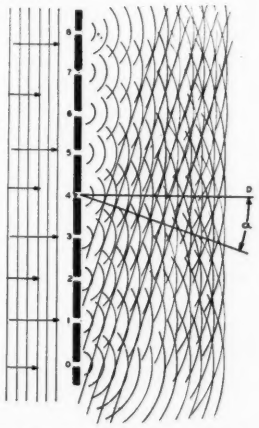


FIG. 3. DIAGRAM OF DIFFRACTION OF WAVES BY A GRID

ahead. In addition, however, the waves just emerging from one opening may combine with the first wave from the next opening, the second from the next and so on, forming a new wave front inclined at a definite angle to the first. The effect will be that shown in Fig. 3. The angle between the two waves is determined by the wave length and the distance between the openings in the grid.

In the same manner, if a beam of light is passed through a series of narrow slits, the rays, after passing through the openings will be bent slightly with the result that the individual rays produced by the slits will interfere with each other. The same result is obtained if a beam of light is reflected from a polished surface on which are engraved a succession of narrow grooves, equally spaced.

Thus, a beam of light, passed through a grating made up of a large number of equally spaced lines ruled on a glass slide, will be split up into three parts, a bright central beam and two faint beams on each side. Projected upon a screen these beams will show themselves as three parallel lines. The bright central line is due to the direct ray, the faint ones to the diffracted rays. If the distance between the lines on the grating is decreased, the separation of the beams is increased, as shown in Fig. 4. In this figure, the upper portion is the direct beam without having passed through a grating. In the center is shown the image of the beam after it has passed through a grating with 100 lines to the inch while the lower portion is the image of the beam after it has passed through a 300-line grating.

This property of diffraction and interference seems to provide abundant proof that light is a wave phenomena; in fact, it was due to these diffraction experiments that the corpuscular theory of Newton lost its hold. Newton held that light consisted of small particles shot out from the light source and which when they entered our eyes gave us the sensation of light. It was impossible, however, to conceive how such particles could absolutely annihilate each other when they met at certain points as indicated by interference experiments. So for a century or more the wave theory of light was generally accepted.

Planck's Theories

Along about 1900, however, Max Planck, who had long been investigating the nature of radiation from hot bodies published the results of his studies. Planck showed that if a body when heated is to become, first red, then yellow and finally white hot, the atomic oscillators in it which produce the radiation must not radiate

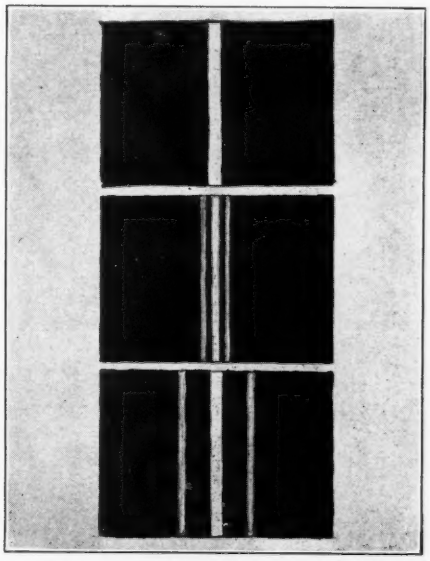


FIG. 4. DIFFRACTION OF LIGHT

The upper portion is the direct beam. The middle portion that through a 100 line to the inch grating and the lower portion is a photograph of the same beam through a grating with 300 lines per inch.

continuously but must radiate little portions of energy at intervals. These quanta of energy, he stated further, must be proportional to the frequency. This was the origin of the celebrated "quantum" theory.

This theory, which has stood the test of time, was something of a bombshell tossed into an unsuspecting scientific world, for as Einstein soon showed, Planck's conclusions would fit exactly with the view that the radiation was *not emitted in waves at all, but as little particles,* each possessing a portion of energy proportional to the frequency of the atomic oscillator as Planck had assumed.[1] So Newton, though he did not have the positive evidence that Planck had, was not altogether on the wrong track in his theory of the nature of light.

[1]What is Light? An address by Prof. A. H. Compton before the American Assoc. for the Advancement of Science. Dec. 28, 1928.

According to this view then, the pulse of radiation which we started to discuss is not a wave at all, but a particle of something. What this something is we do not know except that it is energy.

Planck's theory, soon after its enunciation, was put to test in connection with experiments on the photo-electric effect. It was found that when light falls upon certain metals such as zinc or sodium, the air in the vicinity of these metals became electrically conducting. Evidently, the light in some way was capable of stimulating the atoms in the metal to emit electrons which when projected into the nearby atmosphere rendered the atmosphere partly conducting. With X-rays this effect is even more noticeable since with these rays, electrons are ejected from all sorts of substances. These electrons, shot out from substances under excitation by X-rays or light are called photo-electrons. They are, of course, the same electrons that are produced by any other method, the name photo-electron merely denoting the means of ejection.

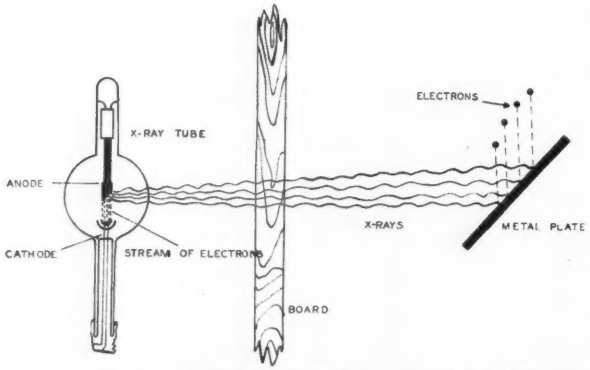


FIG. 5. ELECTRON EMISSION FROM A METAL PLATE BY MEANS OF X-RAYS

X-rays from the tube pass through a board and stimulate the atoms of the plate to emit electrons. The emitted electrons have practically the same speed as the electrons striking against the target in the X-ray tube.

Knowing this action, we may perform a remarkable experiment. Suppose an X-ray tube is arranged so that a beam of X-rays is projected through a heavy wooden board onto a metal plate set at an angle of 45 deg. as shown in Fig. 5. When the X-ray tube is set in operation the action will be as follows: Electrons emitted from the filament of the X-ray tube are drawn across to the anode at a speed dependent upon the voltage on the tube. These electrons striking the anode produce a beam of X-rays which pass through the board to the metal plate. Here the rays excite the atoms of the metal causing them to expel photo-electrons.

Thus, we have an effect which is exactly the converse of the production of light or X-rays by electronic impact described in the previous article. There it was shown that when a stream of swiftly moving electrons is directed against a metal target, X-rays were emitted at the target as a result of the atomic disturbances in the metal. Now we find that when a beam of X-rays is directed at the target, electrons are emitted.

The foregoing experiment in itself is remarkable enough but what is more astonishing, is that the photo-electrons expelled from the metal plate *have practically the same speed as that of the electrons striking the anode* in the X-ray tube!

The real significance of this action is perhaps best illustrated by a story which Professor Arthur Compton related in a lecture on "What Is Light?" before the American Association for the Advancement of Science, and which appeared in the April, 1929, number of the Scientific Monthly. The story relates to an experience he had in his early boyhood.

"During the summer vacations," said Prof. Compton, "my father would take our family to a lake in northern Michigan. My older brother with several of the older boys, built a diving pier around the point a half mile away from the camp where the water was deep. Fearing lest something should happen, my mother would not allow us younger boys to swim in this deep water. So we built a diving pier of our own in shallow water in front of the camp. It so happened, one hot, calm July day, that my brother dove from his diving board into the deep water. The ripples from the resulting splash of course spread over the lake. By the time they had gone around the point to where I was swimming, half a mile away, they were of course much too small to notice. You can imagine my surprise, therefore, when these insignificant ripples, striking me as I was swimming under our diving pier, suddenly lifted me bodily from the water and set me on the diving board!"

"Absurd" you will say. "Such a thing is impossible." Well, that was Professor Compton's contention. If it is impossible for water ripples to do such a thing, it is equally impossible for an ether ripple sent out where an electron dives into a target in an X-ray tube to jerk an electron out of a second piece of metal with a speed equal to that of the first electron.

This effect, it will be evident, will be possible only if all the energy of the impacting electron is converted into a single lump which is ejected as a unit. This lump of energy carries with it all the energy of the impacting electron so, naturally, upon striking another electron, this energy will be just sufficient to eject it at the same speed as that of the electron producing the lump of energy.

Of course, in a ray of light or X-rays, there must be countless numbers of such lumps or particles of energy, each one, however, carrying no more nor no less than the energy of a single electron. These particles of energy have been called photons. Thus when a swiftly moving electron collides with an atom, the kinetic energy of the electron is transformed into a photon, that is, into a particle or bundle of X-rays or light which moves at the speed of light.

This then answers our question as to what becomes of the energy in the pulse of radiation. It travels through space unchanged until it meets with an atom. If that atom is capable of receiving the energy of the pulse of radiation or photon, the energy will be utilized in displacing or ejecting an electron. This electron upon colliding with another atom may cause another photon to be ejected. In this way the energy represented by the original displacement of an electron is handed on from atom to atom. Whether the atoms are close together or whether they are situated at opposite sides of the Universe, this energy transfer will be the same. Coming across countless millions of light years of space, the energy of the photon, it seems, is never lost.

While we have explained the method of energy transfer between atoms through the agency of radiation, the reader, no doubt, will wonder what it is all about. What are these things, the electron and the photon? Is light a wave motion or does it consist of particles? If the electron is a particle as we have said it was, and if the photon is a particle, what is the difference between them? These questions and many more will mystify him and make him inclined to lose faith.

While a more detailed discussion of these questions must be deferred until later, we may state here that in answer to the question, is light a wave or a particle, recent investigation seems to indicate that it is both. In view of present knowledge the photon seems to be both a wave and a particle and this is also true of the electron. The ideas underlying these concepts, however, will be discussed later.

Effect of Interconnection on Power Generation*

INTERCONNECTION HAS permitted the size of generating units to be greatly increased so that units of 100,000 or 150,000 kw. are becoming common, while even larger units are under construction. In most of the instances where such large units are being placed in service they are for the principal use of one operating company rather than for the joint use of parties doing interconnection. Individual companies, however, are in reality composed of a number of smaller companies, which have previously been interconnected. Interconnection of companies has permitted the total reserve of the district to be decreased, since the individual parties need not independently provide for their own emergencies. The increased size of units results in a decreased investment per kilowatt of capacity while the reduced kilowatt capacity still further reduces the investment in power generation apparatus. Another feature which made possible the installation of large size units is the fact that interconnection permits a standard construction program so that one company can make a larger addition than it would be justified in making alone and investment charges can in part be carried by other interconnecting companies.

Reasons for Interconnection

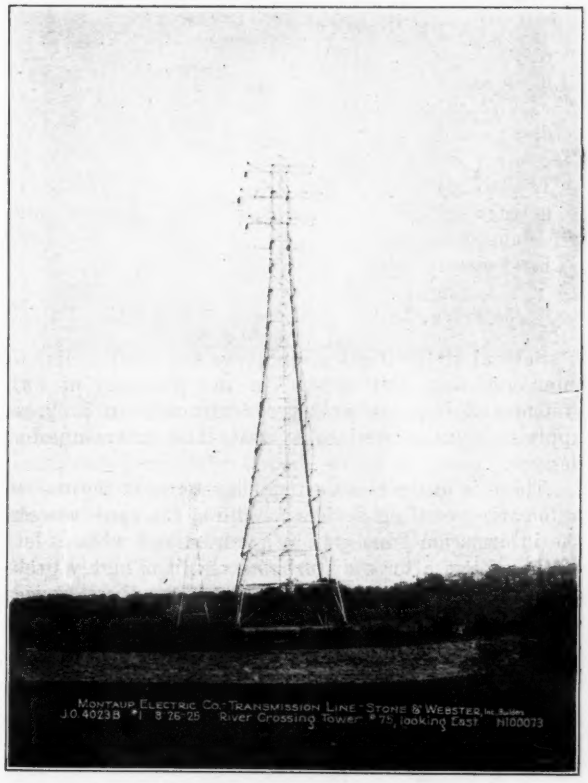
Consumption of fuel is reduced because of the possibility of giving the more economical units the main load of an entire district, because water power can be used more effectively. There are a number of examples where the power which could be developed from stream flow plants during certain hours of the day was weakest and is now used due to interconnection of systems, which gives a greater outlet for the energy.

By far the largest number of interconnections has been of the type where small systems have been merged financially with larger systems and the natural tendency was to abandon the smaller of the generating stations and interconnect systems. Much of this has been done without detailed study as to the possible economy, the problem being considered in the light of the consolidation of properties.

*From the annual report of the committee on power generation of the A.I.E.E. presented at the summer convention of the A.I.E.E. at Swampscott, Mass., June 24-28, 1929.

There are also a number of interconnections between large systems having separate management. These interconnections are made for one or more of the following reasons of economy or improved reliability of service.

a. Generating reserve,
b. Low diversities,
c. Mutual assistance during emergencies,
d. Minimizing possibility of territorial power shortages,
e. Utilization of water power,
f. Additional business due to coverage of intervening areas.


MONTAUP ELECTRIC CO. TRANSMISSION LINE STONE & WEBSTER, Inc. Boston
J.O. 4023B #1 8-26-25 River Crossing Tower #75, looking East M100073

RIVER CROSSING TOWERS ON THE MONTAUP ELECTRIC CO., TRANSMISSION LINE

In the final analysis the primary object of interconnection is, of course, a reduction in investment and operating costs. Presumably it is possible to build and operate an independent system which will give the equivalent of a system interconnected with others, but interconnection affords a more economical method of accomplishing the desired results.

Methods of Interconnecting

Of the two methods of interconnection, namely, loose and tight linking, no conclusions given in favor of one or the other appear to be generally applicable. The distinction at the present time seems to be principally that of pressure. Where loose linking is in operation, the primary object is to provide facilities for the interchange of power for known requirements and where a certain amount of time can be allowed for connecting. In this case the member systems of an interconnection are each capable of providing for their

own requirements with the exception that provision is made for the actual transfer of load by switching to take care of any inequality between the two loads and available generating capacity. Thus, to a certain extent, all of the possible benefits of interconnection are not realized, but on the other hand, some of the complications are avoided. Where tight linking and trunk line ties are employed, the facilities of the group are at all times available to each of the member systems. The complication and expense of the interconnection ties, however, are greatest with this condition.

Problems of Interconnection

At the present time the principal problems appear to be in connection with the following subjects:

a. Load control
b. Load exciter
c. Voltage control
d. Frequency control
e. Relaying
f. Stability
g. Increased short circuit current and adequate circuit breakers and other equipment
h. Communication
i. Metering
j. Technical basis of contractual relations.

Several of the items given above are not peculiar to interconnection, but appear in the planning of any system and improvements are continually in progress applying equally well to separate and interconnected designs.

There is an increasing tendency towards the use of automatic recording devices for filling the gaps between the information from station operated and what is left of the system after a disturbance and it is highly probable that when accurate information from these devices can be provided on systems throughout the country over a period of time some very constructive new ideas will result.

Specific heat is a widely used engineering term and is a measure of the heat capacity of a material whether it be solid, liquid or gaseous. With the exception of hydrogen, water has the greatest specific heat and is taken as 1.00, the standard of measurement for solids and liquids. Hydrogen is commonly taken as the standard for gas.

This ratio of specific heat is merely a relative term and to be evaluated must be considered with the standard heat unit. The quantity of heat necessary to raise one pound of water one degree F. is known as the B.t.u. and is the standard unit in English speaking countries. The corresponding metric unit is the calorie, the quantity of heat required to raise one Kilo (2.2 lb.) of water one degree c. (1.8 deg. F.). It is equal to 3.96 B.t.u.

This is analogous to, but a somewhat simpler relation, than the terms specific weight and density. Specific weight is the ratio of the weight of a material to an equal volume of water, while density is the weight per cubic foot. To determine the unit weight or density of a material, it is necessary to multiply the specific gravity by the density of water or 62.5 lb. per cu. ft.

The Maintenance of Motor Switchgear

By W. E. Warner

MOTOR STARTING switchgear can be divided into two classes, direct current and alternating current starters. An ordinary faceplate direct current starter consists of the fixed contact studs on the resistances, the movable contact arm together with an overload and no voltage release and the main switch, circuit breaker or fuses. These starters should be examined periodically to ascertain the condition of the contacts and the strength of the insulation. Each time the starter is operated the fixed contacts are heated and in time a layer of oxide and dirt tends to form on their surface, preventing good contact and causing overheating. These contacts can best be cleaned by placing a strip of fine sand paper under the movable starter arm, the rough side on the contacts, and working the arm backward and forward over the contacts. The brush lamina on the starter arm must be kept clean and free to move and each leaf must bed on the contact block. All dust and dirt should be removed by blowing out with bellows and cleaning with a cloth.

In one instance where a motor starter was located in a steel grinding shop, the resistances burned out through steel dust settling on them and their porcelain supports, finally causing a short circuit. The cause of the dust settling on the resistances was through their having steel supports, these in time becoming magnetized by the current passing round them and this magnetism passing through the external porcelain support caused steel dust to be attracted to this and settle on the porcelain and resistance wire.

Where steel dust is in the atmosphere, brass rods should always be used for supporting the porcelain, and the resistance coils should be blown out periodically to prevent the settlement of dust which would cause a short circuit. On alternating current starters a cause of no voltage coils burning out prematurely is the sticking of the plunger due to dirt. When a plunger sticks the current in the coil is many times normal and will probably burn the coil out. These plungers should be removed from time to time to see if clean and working freely; they may be lubricated with a faint trace of thin oil to prevent rusting, but a large quantity or a thick lubricant should not be used as this would congeal and cause sticking. The contacts should be attended to as with d. c. starters.

Where oil-cooled auto transformer starters are used it must be remembered that these are not suitable for continuous starting and if the starter is operated more than four or five times in one hour, the oil will be overheated and the starter will give trouble.

Three successful plans for carrying power plant peak loads involve the use of steam accumulators, high peak load turbines and the continued use of present plants for peaks after base load plants are constructed. This is true because, in peak load plants, the major portion of the charge or cost per kilowatt-hour are fixed charges, labor, fuel and maintenance being relatively unimportant.

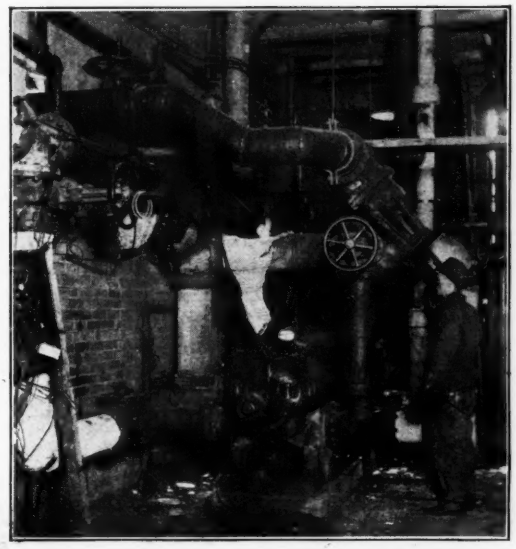
WELDING *in* Power Plant Construction and Repair

DISCUSSION OF SOME OF THE WAYS BY WHICH THE POWER PLANT ENGINEER CAN SAVE TIME AND MONEY BY PROPER USE OF VARIOUS MODERN METHODS OF WELDING

NOT ONLY have autogenous and electric welding established a permanent place among methods of repair of equipment but they are now considered indispensable in the fabrication of equipment in the shop. In power plant construction and maintenance, many opportunities present themselves to use welding in erection of structural steel, erection and repair of tanks, ducts and similar equipment, fabrication, alterations and repairs on piping and repairs to castings and machinery parts.

Forge welding, until about 40 yr. ago, had been for centuries the only available method. Then electric resistance welding was developed. In this process, the parts to be joined are shaped, pressed together and a large current is then passed through the joint until it has reached welding temperature. At present, on work of any size or for quantity production, the machines used for this work are not readily portable, hence are used more in fabrication work than in maintenance.

Electric arc welding and oxy-acetylene welding are the types most used by the power plant engineer. The atomic hydrogen arc process gives promise of many advantages for this type of work, although it has not yet attained such wide application as the other two. Thermit welding has also been used for many power plant jobs. Equipment used in these processes can be taken to the job in most cases. Furthermore, with proper care, good welders can be developed from the plant operating force itself and, if that is not desirable, outside welding companies can usually be obtained that can perform satisfactory work. Some engineers hesitate to use welded piping for extremely high pressures, because of the difficulty of completely testing welds in place, but for ordinary low and medium pressure piping, welding has given widespread satisfaction. Welding of pressure vessels is still a subject of controversy and it is questionable whether any one but a manufacturer fully equipped for this work should be allowed to attempt it.



Most of the welding work done by power plant engineers depends for its success on the skill and thoroughness of the welding operator. Use of proper equipment is, of course, essential but the manufacturers of the equipment can be depended upon for this. Wherever possible, it is well to have welding operators trained by the manufacturer who supplies the equipment, since the

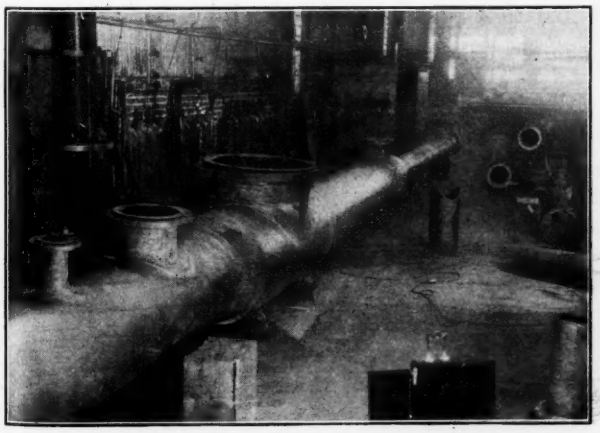


FIG. 1. OXY-ACETYLENE-WELDED HEADER 56 FT. LONG, OF PIPE VARYING FROM 12 TO 30 IN.

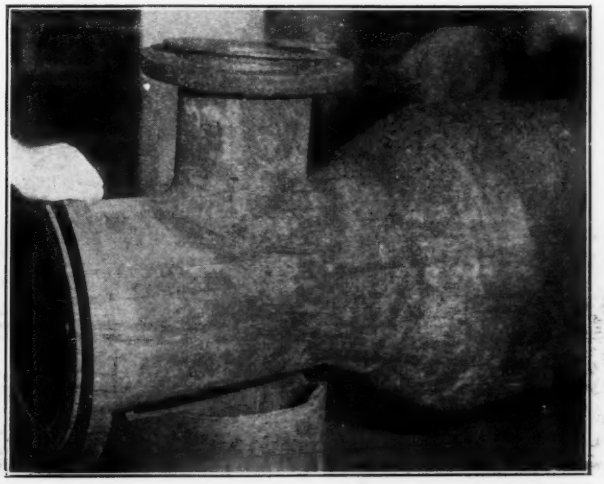


FIG. 2. SWAGED AND WELDED REDUCING JOINT ON HEADER SHOWN IN FIG. 1

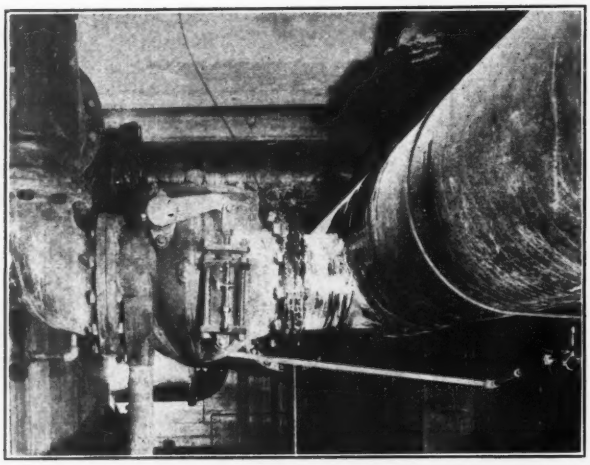


FIG. 3. PIPING ALTERATION, REPLACING 14-IN. EXHAUST LINE BY 24-IN. LINE AT RIGHT, COMPLETED IN LIMITED SPACE BY WELDING

manufacturer has gone to much trouble and expense to develop equipment and methods that will give good results and it is to his interest that it should be used properly.

Structures and parts to be welded should be properly designed, of course, not only for the loads they are to carry but also to conform to the requirements of the particular welding process used. It is not enough merely to substitute welding for riveting on a job designed for riveting. For example, on riveted structural joints plates might be overlapped or straps used, whereas if these joints were welded, butt joints might be employed. It is evident that the design of the structural parts would be different in the two cases.

Skill of operators, in most cases, can be determined only by testing specimens of his work, preferably testing them to destruction. Importance of proper inspection, supervision and testing of welding can scarcely be overemphasized. Procedure control has been worked out for various conditions by several of the makers of welding equipment, to aid in determining the success of welds. A procedure control is a detailed production specification covering: a, check of welder's ability; b, selection and inspection of materials; c, design and layout of joints; d, preparation for welding; e, welding technique; f, inspection and test. Several methods now under investigation for determining accurately the success of welds in place give promise of dependable results.

Applications of welding in power plant work are numerous and only some of the most important will be touched upon here. The ingenuity of the welder can often solve difficult problems as they arise. Welded piping is probably most familiar to engineers as it has been so frequently used. In the headpiece, an operator using the oxy-acetylene blow pipe is welding in a branch connection on a water line to a pump. Figure 1 shows a welded header forming part of the exhaust steam system leading from five compressors to a barometric condenser. This header, 56 ft. long, is made of steel pipe varying from 12 to 30 in. in diameter. A swaged and welded reducing joint on this header is shown in Fig. 2. The picture on the contents page of this issue shows an electric arc welder at work on an outside steam line about 1700 ft. long. This 12-in. line carries process steam at 150 lb. pressure. On the same supporting structures another 6-in. line carries steam, a third line carries condensate and the fourth compressed air. After all these lines were welded over the entire 1700 ft., only two leaks were found, it is stated, one in the 12-in. and one in the 6-in. line.

FIG. 5. JOINING STRUCTURAL BEAMS OF A LARGE OFFICE BUILDING BY ELECTRIC WELDING

Figure 3 shows an alteration made possible in extremely limited space by welding. Installation of a new turbine at this plant necessitated replacement of the 14-in. low-pressure exhaust line with a 24-in. line. The new 24-in. main is shown at the upper right, with connection, welded by the oxy-acetylene process, for a 14-in. line to the relief valve.

Welding of structural steel is being carried out more

FIG. 4. BRACKET WELDED TO I-BEAM

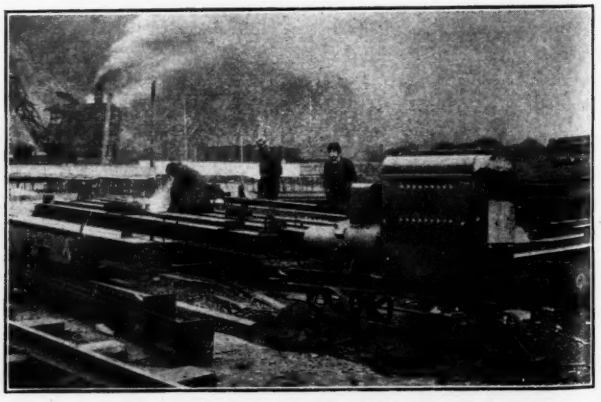


FIG. 6. FIELD-WELDING STRUCTURAL BEAMS WITH A GASOLINE-DRIVEN ARC WELDING SET

and more frequently both for industrial buildings and commercial buildings. In the power plant and in the industrial departments, the engineer has an opportunity to exercise considerable ingenuity in welding structural steel parts. Platforms, machine foundations, brackets for attachment of machinery to columns and many similar jobs can be done cheaply and quickly by welding. Figure 4 shows a bracket welded to an I-beam. Figure 5 shows a welder joining two structural steel parts of an office building. Steel work for this building was joined entirely by the electric arc process. Field welding of structural beams by the electric arc method is shown in Fig. 6; a gas-engine-driven arc welding set is employed here.

Use of structural steel members for machinery bases and similar structures is illustrated in Fig. 7. At the right is an arc-welded steel base for a paper-box-making machine, with its cast-iron predecessor in the foreground.

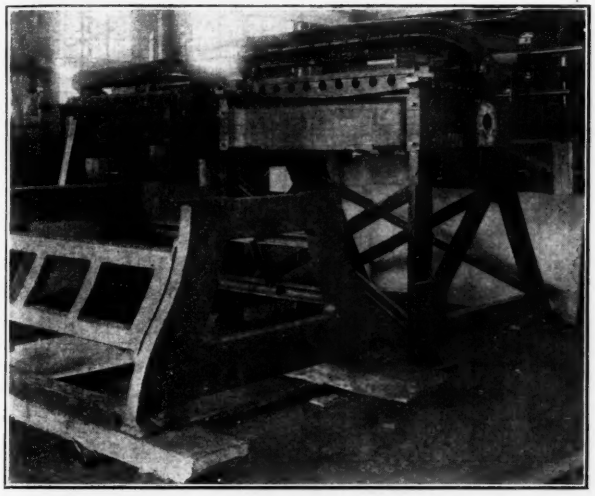


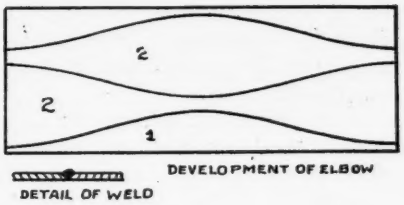
FIG. 7. AT RIGHT, ARC WELDED STEEL BASE, WITH ITS CAST-IRON PREDECESSOR IN FOREGROUND

Figure 8 shows a welded air duct, of circular cross-section. Such a duct is typical of the sort of job the engineer may often be called upon to do either in the power plant or in the industrial departments. The straight sections with longitudinal butt welds are simple, as are the ring angles. Pieces for the elbow were laid out in the drafting room by computation, so that all the shop had to do was to lay out the co-ordinates to the dimensions given. If the cutting on such work is done by torch, suitable cutting allowance must be made. After cutting, the plates were rolled to form and longitudinal seams butt welded; the pieces were then tacked and the circumferential welds completed.

In Fig. 9, a welder is preparing to repair a large casting by arc welding. The gap was welded together and was then covered by a plate welded over the whole, forming a joint stronger than the original metal. The repair cost $250 and the service loss saved was over $350 a day for a 3-weeks delay period.

Repairs on pistons, engine and compressor parts can often be made by welding that will show similar savings. Worn, pitted or eroded water wheel blades, pump impellers or similar parts can be built up to full size by welding. By the use of suitable welding rod and flux, if necessary, and by proper application of oxy-acetylene flame or electric arc, almost any metals can now be welded. Chromium alloys, manganese steel, aluminum, monel metal, nickel, copper and bronze can all be welded nowadays if sufficient care is taken to follow directions for welding these as supplied by the makers of welding equipment.

Where welding is done under shop conditions, welders are required to prepare test coupons, which are sent to a testing laboratory for a complete test. In the field, testing is more difficult. A bend test can be made on a welded coupon by bending it in a vise, having first put gage marks on it. From the increase in the distance between the marks after repeated bending, the elongation may be calculated. In an average weld this elongation may be about 20 per cent for a weld in mild steel plate. For testing tensile strength of welds in the field, a portable testing machine has now been developed. In pipe line work, some method of cutting test specimens from the line itself is often desirable. In one case, this was done with a portable keyway-slotting machine fitted with two thin milling cutters and a spacer instead of with the broad cutter used for keyways. This machine is set up on the pipe and the specimen thus cut out is polished and etched.



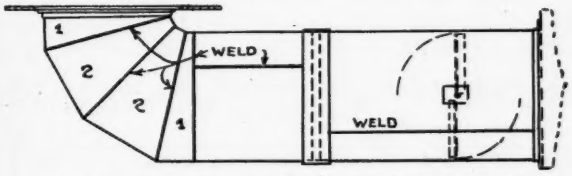


FIG. 8. AIR DUCT DESIGNED FOR WELDING

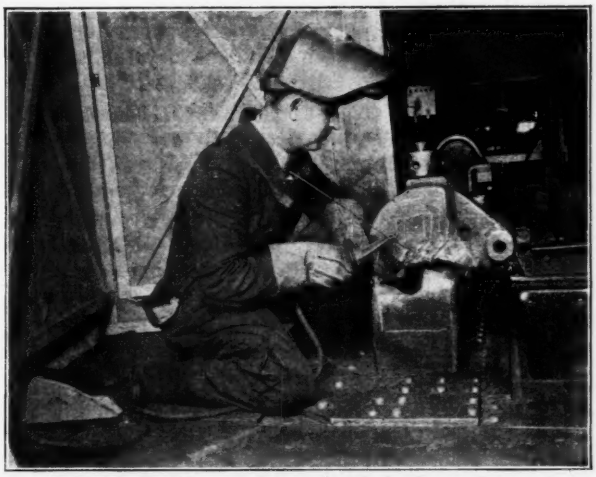


FIG. 9. REPAIRING A CASTING BY ELECTRIC WELDING

Proper safety precautions must be taken in handling and storing oxygen and acetylene tanks and in using the torch, while with the electric arc, safety methods must be observed in regard to grounding, cables, insulation and so on.

Distributing Steam Charges in Industrial Plants

PRESSURE, TEMPERATURE AND FLOW MEASUREMENTS, LOSSES IN PIPING, RADIATION LOSSES

DETERMINATION of conditions in the steam distributing system of a power plant must often be made, especially in the industrial plant, to distribute the charges for steam to the apparatus that is using it. Other conditions may have to be determined, such as pressure drops in the various lines, pressure, temperatures and quality of the steam at various points, radiation loss from piping and performance of the various steam using equipment.

The most common method of determining the amount of steam flowing to a certain piece of apparatus is to insert a steam flow meter in the line just ahead of it. In industrial plants, to distribute charges of steam to the various departments, a flow meter is usually installed in each outgoing steam main and the recording or indicating devices of all these lines can be mounted on a gage board in the engineer's office, together with a meter indicating total steam produced.

RADIATION OF BARE AND COVERED PIPE, IN B.T.U. PER SQ. FT. PER HR. PER DEGREE TEMPERATURE DIFFERENCE

Size of Pipe Inches	Thickness of Covering, Inches					Bare Pipe
	1/2	3/4	1	1-1/4	1-1/2	
2	.472	.374	.314	.272	.250	1.89
4	.787	.615	.510	.443	.392	3.46
6	1.12	.857	.705	.573	.532	4.95
8	1.40	1.07	.874	.744	.655	6.31
10	1.74	1.32	1.07	.908	.792	7.79

Sometimes, if all the condensate is to be returned to the boiler room, as in steam heating systems, it may be more convenient to measure this condensate with some form of weir meter or other type of water meter, rather than to meter the outgoing steam. In some cases, where steam is supplied for process work in which it is condensed, it is impossible or too expensive to meter it. In such cases, steam heated steam generators have been used in which the required low pressure steam is generated by high pressure steam, the condensate from which is brought back and metered with condensation meters.

Pressure and temperature in the steam system are measured with pressure gages and thermometers of the types previously described. Remote recording pressure gages are useful on long lines, having been used for distances of several thousand feet on steam heating mains, to keep the boiler plant informed of the pressure conditions at the far end of the system.

Moisture in steam passing through the lines can be determined with steam calorimeters in the usual way, as previously described. If the steam leaving the boiler is dry saturated steam, moisture trapped out of the lines by separators or other devices is condensate due to heat losses in the lines.

Pipe lines should have the lowest possible pressure losses and radiation losses consistent with economy. On the average a square foot of bare pipe surface will radiate from 2 to 8 B.t.u. per hr. per degree difference in temperature between steam temperature and air surrounding the pipe. The table shows these losses for bare pipe, also the radiation from covered pipe.

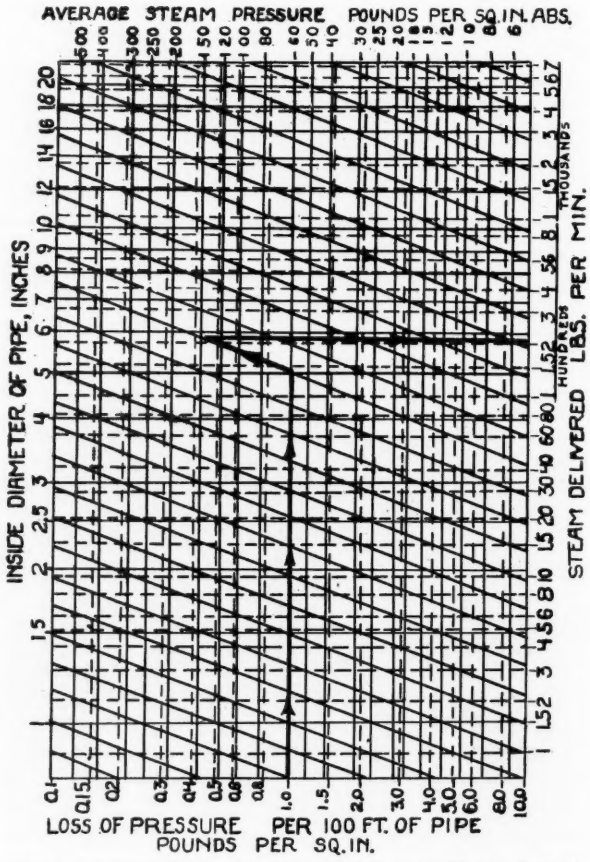

AVERAGE STEAM PRESSURE POUNDS PER SQ. IN. ABS.
INSIDE DIAMETER OF PIPE, INCHES
STEAM DELIVERED LBS. PER MIN.
HUNDREDS
THOUSANDS
LOSS OF PRESSURE PER 100 FT. OF PIPE
POUNDS PER SQ. IN.

CHART SHOWING PRESSURE LOSSES IN STEAM PIPING

Pressure losses in pipes may be checked by pressure gages or often by the steam flow meter on that particular line. These losses for average conditions are about as shown in the chart.

THE AVERAGE engineer feels that the formation of soot takes place on the colder surfaces to which it clings. This is not true, however, as extensive tests by the Bureau of Mines show that this formation takes place within a few inches, a foot at most, of the fuel bed.

Anthracite gives off in distillation volatile consisting almost entirely of carbon monoxide and hydrogen which readily condense with oxygen and so burn with a short flame. High volatile bituminous coals that smoke badly give off in addition heavy tar vapors and hydrocarbons which are unstable and easily broken up into soot, carbon monoxide and hydrogen.

Except under the most unusual conditions, the maximum amount of soot is found about one foot from the surface of the fuel bed, so that cool surfaces upon which it is found does not form it but merely collects it. Soot is different to burn and the only satisfactory method of getting rid of it is to supply sufficient air close to the fuel bed so as to burn the heavy vapors before the heat breaks them down.

Tuning Up an Old Lumber Mill Power Plant

How a Plant That Had Been Mismanaged Was Put Into Good Condition. By R. G. Drees

WHEN I accepted the position as chief engineer for the plant of a lumber company, I was given authority to direct and supervise the general output of power including the dry kilns, in addition to being appointed safety inspector. At the time, the power plant was in the clutches of wreck or ruin. The big Corliss engine rattled and pounded from morning till night. In fact, it labored under a load that it should have handled easily. The boilers were dirty; the piping leaked; the valves could not be closed tight which meant the loss of leaking steam was almost equal to the amount used to run the engine. There was no way of keeping the water glasses cleaned as no blowoff pipe was connected to them. The result was that the water would form a dirty ring inside the glass and the proper water level was always uncertain.

Boilers Were in Bad Condition

Compound was fed into the boilers whenever they were washed out, which meant if wash-out day was overlooked, the inside of the boiler paid the price by the added accumulation of scale and dirt. The boiler feed pump was lame and could deliver only about half the required amount of water, hence the injector was brought into operation to supply the boilers with water. There was no check valve between the boiler and the injector which made the operation of this device dangerous. Oil used was dirty, unfiltered and not fit for even second-hand use.

In the boiler room, the floor was half brick and the other half cement. The brick part would chip off until some of the brick had disappeared, making the floor uneven, rough and always dirty, no matter how often it was cleaned. At some places on the engine room floor the dirt was scraped off with scrapers.

Although the company was willing to buy polish and good waste, it was never used. The bright work on the engine had disappeared; not one spot could be seen. Valves of all different sizes were lying around in the corners. Plainly speaking, the cost of such valuable material was never considered. The word management means operation, care, repair. The successful engineer must not only understand the necessary conditions of working and control, but he must know how to meet the numerous disorders and mishaps that may be encountered as they arise from faulty construction, from careless or ignorant handling such as insufficient lubrication, faulty adjustments, racing, overheating and breakage or wear of parts.

Good Will of Men Essential

The first thing after taking charge was to try to earn the good will of the men working in the plant. From the day I accepted the position, I started a system and today it is in perfect working order. The return-tubular boilers were considered and work was started on them. The gages were tested and the safety valves set to conform with state law and insurance rules.

Leaks in the piping were stopped, the valves were repacked and the old discs replaced by new ones. Boilers were then washed out, the bridge walls and arches renewed, the fronts wire brushed and painted and valve bonnets cleaned. Water columns are now working with clean water glasses and a column blowoff attachment. Also compound is being used every day.

A new cement floor with new steps in the boiler room has made a great change in that department. All reducing valves for the heating system were reground and cleaned. Fuel is not considered for the reason that the sawdust and waste from the mill will more than supply the battery of boilers in use to operate the plant.

To put the boiler feed pump into condition it was taken apart, repacked and cleaned, the hand pump for forcing oil into the cylinder being replaced by a sight feed lubricator. Valves were set and it now works like a top; takes care of the feedwater and travels only one-half the piston speed in feet that it formerly did. The injector was next put in order by grinding and by placing a swing check valve between the delivery of the injector and the boiler.

Tuning Up the Engine

The engine was Corliss type with girder frame, flywheel 17 ft. in diam. with a 24-in. belt 125 ft. long. The engine was taking steam full stroke and every time more than two machines were running the engine would come almost to a standstill. The result was that the machines had to be shut down in order to let the engine pick up to its normal speed which was 78 r.p.m. The speed was first increased to 87 r.p.m. and good oil provided. Then the lost motion was taken out and the valves adjusted; the main shaft lined up; the grease cups removed and telescope oilers put in operation. Today all machines in the mill can be operated at the same time with the engine cutting off at ⅓ stroke. The pounding is gone and the engine is a smooth running piece of machinery ready to go at the opening of the throttle. Every piece of bright work is polished and the engine room is slick and clean.

During the process of repairing, the plant was running every minute. Under no conditions was the mill delayed for power.

As a result of this reconditioning work, the water bill has been cut in half, much of the water being filtered and used over and over again. Personal supervision of all repair work, with no outside help, has put the plant in first rate condition. It is an example of what can be done if one sets himself to achieve the best possible results with the equipment available.

Periodic tests of boiler water should be made regardless of the treatment to which the make-up is subjected. Evaporators, deaerators and chemical treatment have done much to alleviate difficulties from bad feed water. Proper treatment, however, necessitates close control.

Such necessary tests are simple and can be carried out by the regular operating crew. These results should be carefully recorded and preserved for future reference in case difficulty arises. Periodic and more complete tests should be made by a chemist for the double purpose of checking the operators' results and making any changes necessary in the treatment used.

Design of Anchors for Stack Guys

CALCULATION OF STRESSES DUE TO WIND AND THE RESISTANCE OF BURIED ANCHORS AND POSTS. BY C. O. SANDSTROM

METHODS of anchoring the guys of steel stacks by means of "deadmen" or posts, are about as varied as anything in engineering. Deadmen have been made of blocks of concrete, concrete posts, wooden posts, pipe posts, rails and pipe buried horizontally in the ground and screw-anchors such as used to guy telephone poles. One 4 ft. by 90 ft. steel stack in the Middle West was equipped with one set of four guys, each of which was attached to the upper end of a railroad-tie buried ver-

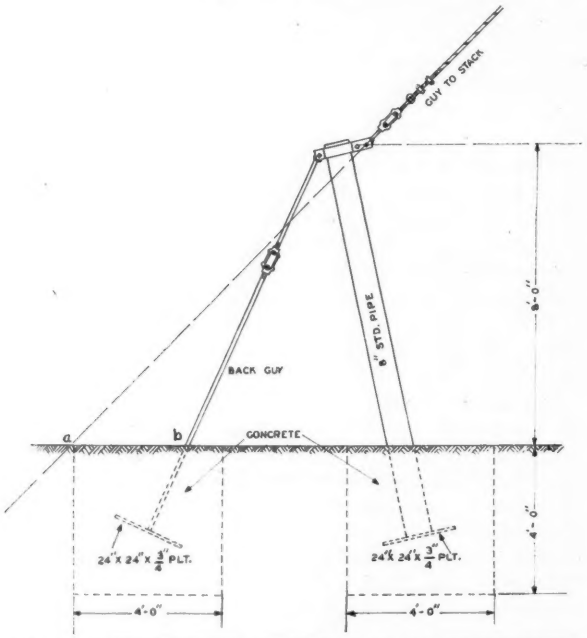


FIG. 1. IN THIS SET OF ANCHORS 75 CU. YD. OF CONCRETE WERE USED WHERE 2 CU. YD. WOULD HAVE BEEN AMPLE

tically half its length in the ground. This stack withstood some heavy storms for a number of years. Railroad-ties buried horizontally in the ground are occasionally used for anchors.

In Fig. 1 is shown how a stack only 50 ft. high has each of its four guys anchored. Conditions may sometimes be met where a post must be used to gain head-room in a limited space but the saving in space is only that represented by the distance between the broken line in the figure and the "back-guy" on the post, or a-b. The construction shown in the figure contains many times the material necessary to anchor the stack sufficiently; in fact one of the blocks of concrete would have been more than necessary. While the construction shown in the figure is one extreme, anchors using railroad-tie posts is the other. No doubt the prevalent notion that guyed stacks cannot be "figured" and that the only thing that can be done is to make the anchorage "strong enough," usually resolves into such practice as described.

Although wind-tunnel experiments in connection with airplane design have thrown much light on the subject, the exact pressure exerted on structures by wind is still uncertain. The results of some of the older experiments, which had been made on comparatively small surfaces, have been found to be too high when applied to regular structures.

While the wind pressures used in design are average values, the actual pressure on a structure varies from a minimum at the base to a maximum at the top because of the varying velocities of the wind incident to friction of the earth's surface. The velocity seems to vary as some fractional power of the height, but for practical purposes may be regarded as uniform.

Building codes specify wind pressures of 30 lb. per sq. ft. or more to be used in the design of flat surface structures. The pressure exerted on cylindrical surfaces such as chimneys has been stated as varying from one-half to two-thirds of the pressure on flat surfaces. Using the value two-thirds and a plane-surface pressure of 30 lb. per sq. ft., the design pressure for chimneys is 20 lb. per sq. ft. of projected area, which seems ample in view of the behavior of chimneys throughout the country that have weathered the storms for many years.

STACK CONSIDERED AS BEAM AND CANTILEVER

Assume a stack 3 ft. in diameter and 60 ft. high with a set of four guys attached 12 ft. from the top, the guys making an angle of 45 deg. with the ground. At 20 lb. per sq. ft. of projected area there is a pressure of 60 lb. per lineal foot of stack. The guyed stack is in practically the condition of a beam supported at one end and at some point in its length, with an overhanging end, or cantilever. In this case the stack is supported at its lower end, and by the guys at an elevation of 48 ft., and may be represented by the diagram of Fig. 2, the reaction R_1 representing the horizontal resistance at the base of the stack, and the reaction R_2 the horizontal resistance at the attachment of the guys to the stack.

As it is the reaction R_2, or the horizontal resistance of the guys that concerns us, we find it by multiplying the load per square foot of projected area by the diameter of the stack, and by the square of the length and divide by twice the distance of the buys from the base, or $20 \times 3 \times 60 \div (2 \times 48) = 2250$ lb. And if the guy makes an angle of 45 deg. with the ground, the stress in it is the force of 2250 multiples by the secant of the angle 45 deg., or $2250 \times 1.4142 = 3180$ lb.

Stated as a formula, the stress in a 45-deg. stack-guy is $\frac{0.705\ WDH^2}{L}$ in which W = weight per lineal foot of the stack, D = diam. of stack in ft., H = height in ft., L = distance from base to the guy-band.

In the foregoing the resistance of the stack itself has been neglected because as usually constructed the inherent stability of a guyed stack is slight.

Two Sets of Guys Seldom Advisable

In the case of a stack equipped with two or more sets of guys, the analysis is much more complicated; approximating the condition of a continuous beam. In a continuous beam, a slight settlement of one of the supports exerts a profound influence on the kinds and magnitudes of stresses; a condition greatly exaggerated in guyed stacks because of the varying resistances of the several guys. With the uncertain conditions attending stacks with more than one set of guys it seems that each set should be made sufficiently strong to support the stack alone in the event of failure of the others.

The thought then occurs, why use more than one set of guys? To the advice, "Never put all your eggs in one basket" can be replied, "Put all your eggs in one basket, *but watch the basket.*" Which principle applied to guyed stacks results in one set of guys for all heights of stacks and made so secure as to preclude any possibility of failure.

In considering a tall stack with a single set of guys, one element of the problem concerns the strength of the stack as a beam between the base and the guys, and another element is its strength as a cantilever above the guys. For example let us use a stack 8 ft. by 150 ft. made of ¼-in. steel plate, assuming it would behave as a tubular beam; that is, there would not be enough local buckling to seriously affect the properties of the section. With the guys attached 20 ft. from the top we would have a beam of 130 ft. span and a cantilever of 20 ft. span. We shall neglect the restraint offered by the cantilever; that is, we shall assume the beam a simple one of 130 ft. span merely supported at the ends. The section modulus of the cross-section of the stack is $0.098\left(\frac{96.25^4 - 96^4}{96.25}\right) = 1814$. With a joint efficiency of 50 per cent and an allowable fiber stress of 12,000 lb. per sq. in., the resisting moment is $1814 \times 0.50 \times 12{,}000 = 10{,}884{,}000$ in. lb., or 907,000 ft. lb. By the simple beam formula, the safe load $W = \frac{907{,}000 \times 8}{130} =$ 55,815 lb. Dividing this by the length and diameter of the stack we get a load capacity of nearly 54 lb. per sq. ft. of projected area, which is greatly in excess of the required 20 lb., so it seems that the stack is perfectly safe considered as a beam. Were the upper end, or cantilever, much longer, the maximum bending moment might occur at the guy-band.

It is evident from the foregoing that more than one set of guys is not needed to give strength to the stack as a beam, therefore the determining factor is probably the guys and their anchorages, or deadmen. By the method shown, the horizontal force at the guy-band is $\frac{20 \times 8 \times 150 \times 150}{2 \times 130} = 13{,}850$ lb., which, multiplied by the secant of 45 deg. makes the stress in a guy $13{,}850 \times 1.4142 = 19{,}580$ lb. A 6-strand 7-wire plow-steel rope ⅞-in. in diameter has an ultimate strength of about 62,000 lb., or a factor of safety of a little more than three for the work at hand. As the rope will seldom or never be called upon to resist such stress, it should be adequate for the purpose.

Design of Anchorage

Having determined the size of the guy-rope, the next step is the design of the anchorage. As stated in the foregoing, the anchorages for guy-ropes vary between extreme limits. Sometimes it is necessary to attach a guy-rope at some height above the ground in order to permit a man or a truck to pass underneath, which calls for a post with a back-guy, or perhaps merely a post. It might be stated in passing that an arrangement of post and back-guy as shown in Fig. 1, is seldom justified, as a simple post of equal capacity can be installed at much less cost.

In the foregoing discussion, it was shown that the 3 ft. by 60 ft. stack required a horizontal force of

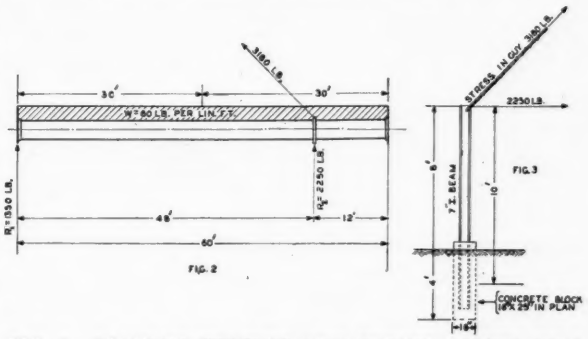


FIG. 2. DIAGRAM SHOWING THE FORCES ACTING ON A STACK

FIG. 3. DIRECTION OF FORCES ACTING ON AN ANCHOR POST

2250 lb. at the guy-band to resist the assumed wind pressure, which force must also be resisted by the anchorage. If the guy were attached to a post 8 ft. from the ground, and the post securely imbedded in concrete, the bending moment in the post is $2250 \times 8 \times 12 = 216{,}000$ in. lb. As this force may seldom or never be applied to the post, a somewhat higher fiber-stress may be used than is customary in building practice. Using a fiber-stress of 20,000 lb. per sq. in., the section-modulus of the post is $\frac{216{,}000}{20{,}000} = 10.8$ which would permit the use of a 7-in. standard I-beam.

In the same manner as with a beam, the dimensions of the concrete base may be determined, an assumption being made for either the depth or the breadth. Assuming a bearing value for the soil of 4000 lb. per sq. ft. and the depth of the base as 4 ft., its breadth is found by the formula $M_b = F_s \times \frac{BD^2}{6}$ in which B is the breadth and D the depth of the base, F_s the maximum fiber-stress of the soil, and M_b the bending-moment. In this case the bending moment is the horizontal component of the pull of the guy-rope multiplied by its distance from the center of the base, or $2250 \times 10 = 22{,}500$ ft. lb. Applying the foregoing formula we find the breadth to be $\frac{6 \times 22{,}500}{4^2 \times 4000} = 2.11$ ft., or 25 in. There-

fore the base should be 25 in. wide buried 48 in. in the ground. The thickness of the concrete need be only about two-thirds the width; in this case 16 in. The arrangement is shown in Fig. 3.

While we assumed a bearing value of the soil of 4000 lb. per sq. ft., this is only the average value. As is well known, the top layers of the soil lack the density of the lower layers, but this need not trouble us in a practical example of the kind discussed. While 4000 lb. per sq. ft. is the value commonly assigned as average value for soils under building foundations, this is in order to limit settlement to a practical minimum. Should settlement occur, the soil is compressed and the bearing value greatly increased. In the case of a guy-anchor, the slack caused by compression of the soil is taken up with the turnbuckle and the resistance greatly increased. An idea of this increase of bearing capacity

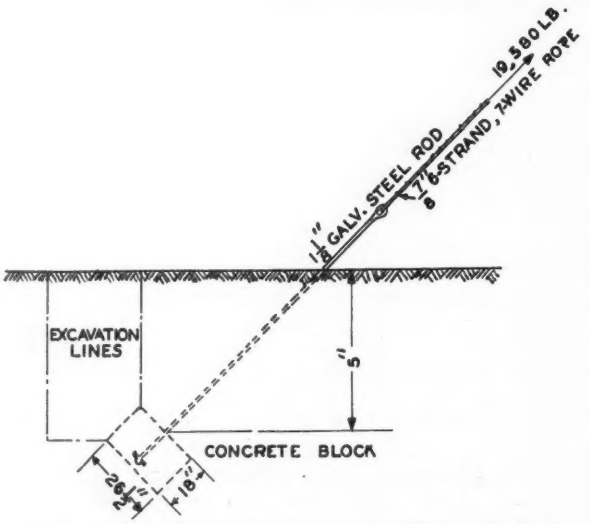


FIG. 4. SIMPLE AND ECONOMICAL ANCHOR DESIGN

may be had by driving a 2 by 4 in. wood stake into the ground and striking one of its sides with a sledge.

Returning to the 8 ft. by 150 ft. stack, we find that the guy-anchor must resist a force of 19,580 lb. The simplest and cheapest anchor would be one buried in the ground, one which depends entirely on direct soil resistance for security. With a bearing value of 4000 lb. per sq. ft., the area of the anchor subject to pressure would be 19,580 ÷ 4000 = 4.9 sq. ft., or 26½ in. sq., if a square anchor be used. The thickness of the anchor if made of concrete not reënforced with steel should be about two-thirds of the width, or 18 in. The rod, made of mild steel and galvanized, may be proportioned for a stress of 20,000 lb. per sq. in. of net cross-section; in this case 19,580 ÷ 20,000 = 0.98 sq. in., or 1⅛ in. in diameter. One has the choice of a rod threaded at the end with the required area at the root of the thread, in this case 1⅜ in. nominal diameter, or a 1⅛-in. rod with one end riveted over the washer and the other formed into an eye by welding as shown in Fig. 4.

The washer at the end of the rod may be proportioned for a bearing stress on the concrete of 600 lb. per sq. in., which calls for an area of 19,580 ÷ 600 = 32.6 sq. in., say 5¾ in. sq., or 6½ in. diameter. The washer is loaded in a manner similar to the piston of a steam-engine, the rod corresponding to the piston-rod and the bearing pressure to the steam-pressure. An important difference is that the washer is restrained by the concrete against deflection, so it may be made somewhat thinner than if it were resisted by a fluid. As the value of the time spent in making what would only be an approximation of the correct thickness of the washer is greater than the cost of the washer, one may select a thickness by judgment. In the case under discussion the thickness may be ⅜ in. to ½ in., because of the comparatively large area of the head on the rod.

If the rod be heavily dip-galvanized it should last as long as the stack, but should there be any concern about its lasting qualities in contact with the soil, it may be laid in a narrow trench and the trench filled with concrete.

Calculation of Anchor Post Dimensions

Were it necessary to have the guys clear the ground at a height as in the case of the smaller stack discussed in the foregoing, the problem may be attacked in the same manner, the dimensions of the post and anchorage being much greater. The horizontal component of the force resisted by the guy of the 8 ft. by 150 ft. stack was 13,850 lb. The bending-moment in a post 8 ft. high would be 13,850 × 8 × 12 = 1,330,000 in. lb. The section-modulus of the post (really a cantilever) with an extreme fiber-stress of 20,000 lb. per sq. in., is 1,330,000 ÷ 20,000 = 66.5. The section-modulus of a 15-in. standard I-beam is 58.9 and may be used. Assuming a depth of anchorage of 7 ft., the "bending-moment" resisted by soil is 13,850 (8 + 7/2) = 159,300 ft. lb. With a 4000 lb. per sq. ft. bearing, the width of the anchor is 6 × 159,300 ÷ (7² × 4000) = 4.88 ft., say 5 ft. The thickness of the anchor should be 3½ ft.

While an anchor of concrete 7 ft. by 5 ft. by 3.5 ft. is quite a chunk, an arrangement consisting of a post and back-guy would cost more unless the back-guy were attached to a pile-like anchor that would take advantage of friction to prevent withdrawal.

In order to economize on concrete one should take full advantage of the maximum soil resistance. The 4000 lb. per sq. ft. used in the discussion is rather under the resistance that would be developed by pulling up the turnbuckle. If the value 8000 lb. were used, the anchor just described would be 6 ft. by 3.5 ft. by 2.5 ft., a saving of more than half the concrete.

Anybody who has observed the holding power of wood stakes, or pipes, driven into the ground as temporary anchors for derricks or hoisting equipment, must marvel at the anchors sometimes provided for the guy-lines of small stacks. Recently there was installed stack guy-anchors to serve three 4 ft. 6 in. by 100 ft. stacks that probably establishes a record in what has been called "by guess and by gosh" engineering. Each stack was provided with anchors in two directions as shown in Fig. 1, except that one of the blocks was 5 ft. by 5 ft. by 5 ft. 6 in. The end anchorages serving the three stacks were blocks of concrete, one of which was 8 ft. 6 in. by 8 ft. by 8 ft. 6 in. and weighed about 42 t. Altogether there was 75 cu. yd. of concrete used to anchor the guys of these three stacks. Two cubic yards of concrete would have provided anchorage, and the remainder, or 73 cu. yd., was a tribute that capital all too frequently pays to mediocrity.

Refrigerating Characteristics of CARBON DIOXIDE

By W. R. WOOLRICH

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Carbon Dioxide when used as a refrigerant possesses many advantages over other more commonly used media. The most important of these are discussed in this article.

EARLY DEVELOPMENTS in CO_2 refrigeration were unusual. When consideration is given to the high pressures to which the carbon dioxide machine must compress the refrigerant, the daring of the early designers and builders of carbon dioxide equipment must command praise.

During this same period of development, steam engineers seldom ventured above 75 to 100 lb. pressure. Air compression was seldom pushed upward beyond 125 lb. High pressures were considered anything above the 150 lb. pressure mark in practically any line of development. The development of CO_2 equipment was not without its hazards. Some serious explosions of CO_2 equipment did occur. But the dangers were incident to its expansive effect; chemically and thermally it had no serious reaction on human life.

The cycle of development so courageously started by the early inventors of CO_2 machines was limited in its possibilities. The ammonia machines demonstrated their apparent superiority over all other refrigerating media and interest in CO_2 refrigeration was expressed only by those demanding an odor-proof machine. Only in marine practice was CO_2 considered the standard refrigerant. And even in marine practice ammonia was a serious competitor in equatorial regions where hot cooling water prevailed.

But an increased activity in carbon dioxide refrigeration has been evident during the last 5 yr. period. Several factors have contributed to this activity. Probably first, the demands of theatre and building owners for a non-odorous refrigerant for auditorium cooling encouraged the introduction of CO_2 machines to some limited land use. Chemical process work demanding very low temperatures created a demand for CO_2 machines because of the impossibility of ammonia to meet the temperature requirements without going below atmospheric pressures on the suction side. The increased pressure boundaries in work with other gases, evidenced by 1200 lb. pressure installation of steam units, created a new confidence and interest in all high-pressure operations including CO_2, and finally, a renewed interest in the possible applications of carbon dioxide compressed snow aroused the romantic nature of experimenters, designers, and financiers, the early results appearing so alluring that the future immediately beckoned to greater successes.

Some Physical Properties of CO_2

On account of the early accepted superiority of ammonia over CO_2 as a commercial refrigerant, CO_2 machine construction remained at a low ebb for many years. Interest in research on the properties of CO_2 likewise displayed little activity. By the nature of the compound, many of the properties were difficult to measure. The inevitable result was that complete data on CO_2 remained meager and unreliable until the renewed commercial interest in the refrigerant encouraged a more exacting study of its properties.

While there still remains some slight divergence of opinion on certain properties of CO_2, most values are sufficiently well known to be considered commercially accurate. The more important of these properties under atmospheric conditions are given in the following table:

PROPERTIES OF CARBON DIOXIDE AT ATMOSPHERIC PRESSURE

Critical Temperature	88.4° F.
Critical Pressure	1071 lb. Abs.
Melting Point	—160.6° F.
Boiling Point	—109° F.
Latent Heat of Fusion	81.5 B.t.u.
Latent Heat of Vaporization	158.6 B.t.u.
Specific Gravity	1.53
Specific Heat at Constant Pressure	0.203

Characteristics of CO_2 in Solid Form

Compressed carbon dioxide snow or "dry ice" has found a very satisfactory commercial application as a refrigerating agent in the shipping of ice cream. At present writing, fully 90 per cent of the dry ice made is used for ice cream shipping packages. Such packages are safely sent by either mail or express. Its two peculiar advantages are, its complete disappearance upon vaporization, and its high insulating and cooling capacity.

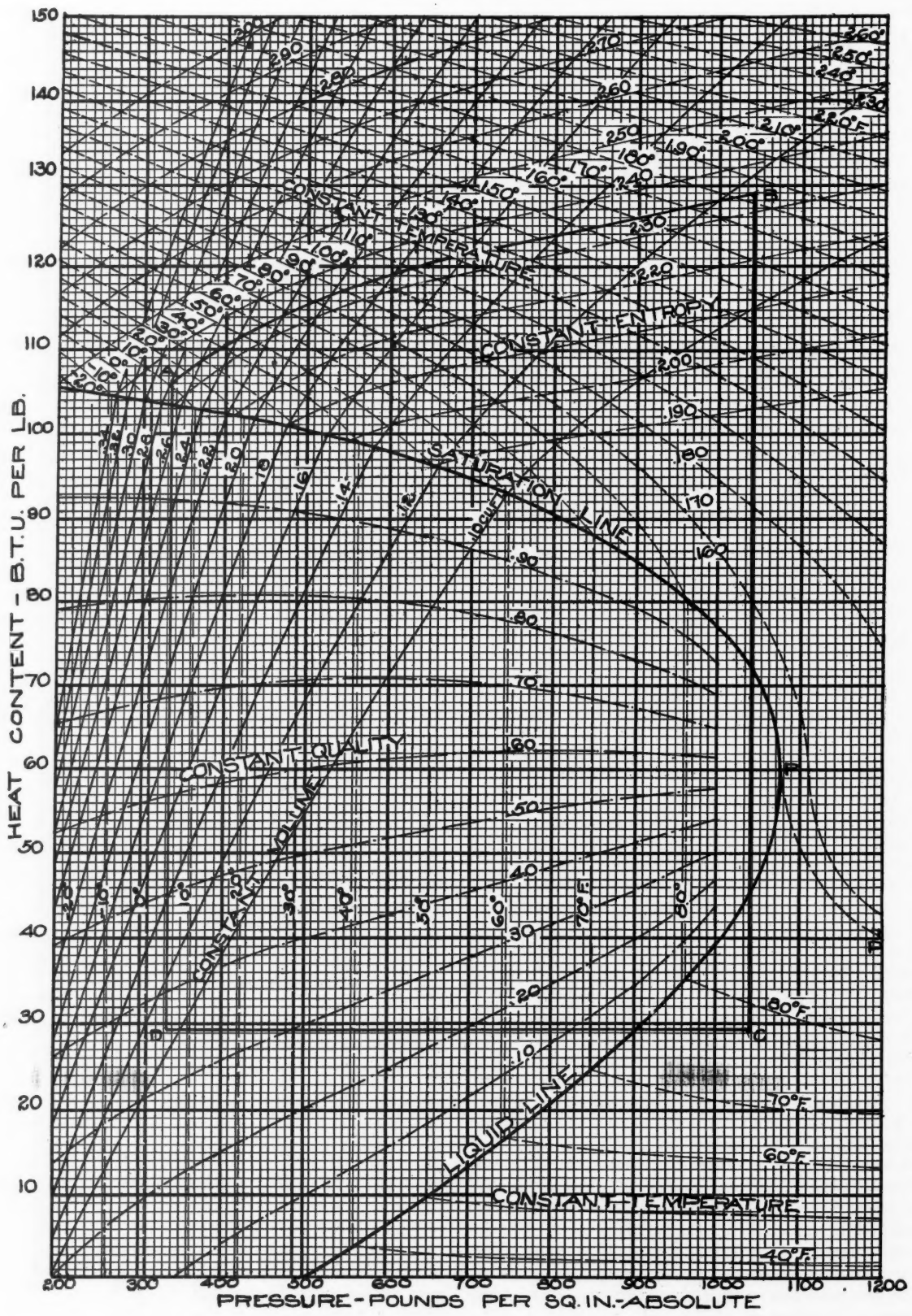


DIAGRAM OF CO_2 PROPERTIES WITH STANDARD TON CYCLE FOR CO_2 IN OUTLINE

By mathematical calculations, the apparent heat absorbing capacity of a pound of dry ice is less than that of two pounds of water ice. The heat absorbing capacity of water ice from and at 212 deg. F. is 144 B.t.u. J. W. Martin, Jr., of New York City gives the amount of heat absorbed by prepared blocks of CO_2 snow in passing from the solid to the liquid state up to 0 deg. F. as 276 B.t.u. This would indicate less than a two to one ratio for the comparative heat absorbing capacity of dry ice and water ice.

But the insulating property of the CO_2 gas, set free in the subliming of CO_2 snow, is its most favorable characteristic. Its ability to blanket itself and immediate surroundings with CO_2 gas makes possible a much more efficient use of CO_2 than can be realized from water ice.

Dry ice refrigeration must depend upon the care and methods used in taking advantage of its self-insulating properties. This must necessarily involve specially designed carriers and containers for its economical use. And its use will be restricted to the refrigeration of perishables in transit or to very specialized home and industrial demands. In this field it is not entirely new as records indicate its common use by the English official staff to make cooled drinks available in the more remote sections of India as many as 30 yr. ago.

Economics of Dry Ice

Best figures available place the present cost of dry ice at $100.00 per ton. This figure is based on a daily output of 35 tons. This high figure at first seems discouraging when we consider that water ice has been sold in large quantity deliveries at 70 cents per ton and retailed in ton lots at $2.50 per ton.

But with increased demand, CO_2 has great possibilities in cost reduction. As raw material, the supply is unlimited, and can be secured from a great variety of sources and processes. Its commercial manufacture will adapt itself to production on "dump power" or similar electric rates which should eventually lower the actual power consumption to $3.00 to $10.00 per ton. It should not be too optimistic an expectation to forecast dry ice at $1.00 per 100 lb. on commercial contracts to large users.

CO_2 in Refrigerator Car Operation

The refrigerator car has become a very essential part of our American life. Their numbers now reach the hundreds of thousands. While they are operated in one direction of transit as refrigerator cars, usually a return perishable load cannot be found and they are used to carry straight freight on the return trip. When carrying loads that must be cooled, these cars require frequent reicing. This is at a considerable loss of switching time and represents some loss to the shipper in both spoilage and additional interest on the delayed shipment.

Probably water ice will never be replaced for much of this service. Often the value of the shipment is not great enough to encourage substitution to better, but more expensive methods of refrigeration. But for more highly valued shipments some better form of refrigeration is very much to be desired.

While the original separate experiments with silica gel and with solid carbon dioxide are both in the development stage, applications for each are to be anticipated. Present day shipments with either of these refrigerating processes must necessarily be confined to the refrigeration of shipments of considerable value. Furthermore, the destination must be definitely known, for until a very complete system of servicing is established on all roads, the possibility of these specially equipped cars being diverted to some remote delivery point would bring some experiences ruinous to the industry.

Among the distinct advantages of CO_2 compressed snow as car refrigerant will be largely in its (a) low weight for large refrigerating capacity, (b) non-rotting action on the car itself, (c) ability to give a wide range of temperature control, (d) adaptability to a car construction that will permit water ice substitution under emergencies.

More recent developments requiring shipment of cold packed fruits and eggs under freezer conditions can be met readily by CO_2 as the refrigerant without icing delays. While railroads will hesitate to commit themselves to these new refrigerants until proven fool proof, and until they can adjust themselves with regard to their existing contracts with icing companies, a steady future growth can be anticipated in these new methods of car refrigeration.

Some Unfortunate Traditions of CO_2 Compression

Much of the objection to CO_2 compression has arisen from the traditional belief that it is hard to handle, and that the horsepower requirements are excessive.

Much of the fear of handling can be directly traceable to the high pressures encountered in CO_2 compression. Uneasiness as to what might happen has been more serious than any actual performance experienced. Other than mechanical rupture no damage is possible under any normal working conditions, and mechanical rupture at the low temperatures encountered is very improbable. The horsepower requirements have been variously stated as being excessively high even to a theoretical requirement of three or four horsepower per ton of refrigeration. An analysis of any reliable heat diagram giving the standard ton cycle for CO_2 will give approximately the following "standard ton" data:

Temperature of refrigerant on low side of expansion valve	5 deg. F.
Pressure of refrigerant on low side of expansion valve	333 lb.
Heat value of refrigerant on low side of expansion valve	29.4 B.t.u.
Temperature of refrigerant at suction	14 deg. F.
Heat value of refrigerant at suction	106.2 B.t.u.
Entropy of refrigerant at suction	0.234
Temperature of refrigerant at compressor discharge	184 deg. F.
Heat value of refrigerant at compressor discharge	129 B.t.u.
Pressure of refrigerant at discharge	1039 lb. Abs.

The computed horsepower requirements will be the heat added by the compressor per hour multiplied by the amount of refrigerant required per ton.

Since it requires the extraction of 200 B.t.u. per minute to give a ton of refrigeration, the amount of CO_2 required under the above conditions per ton of

refrigeration will be 200 ÷ (106.2 — 29.4) or 2.6 lb. of CO_2.

From the data it is evident that the compressor is adding 129 — 106.2 = 22.8 B.t.u. to each pound of CO_2 pumped through the system.

The theoretical horsepower requirements per ton of refrigeration will be, therefore, the amount of heat added to each pound of CO_2 multiplied by the lb. of CO_2 required divided by the horsepower-hour heat equivalent or 42.5 B.t.u. This will give us the following equation:

$$\frac{2.6 \times 22.8}{42.5} = 1.395 \text{ hp. per ton}$$

The CO_2 Machine and the Critical Temperature

By critical temperature is meant that temperature above which it is impossible to liquefy gas no matter what pressure is exerted. This temperature for CO_2 is 88.4 deg. F. The liquid and vapor line on the CO_2 pressure heat value chart meet at this temperature with a corresponding pressure of 1039 lb.

The constant temperature dash line PP' passing through 88.4 deg. F. below the superheated area will be the locus of the corresponding pressures at which the liquid will become a gas. Below this line the CO_2 should be in liquid form. Above this line it should be a superheated CO_2 vapor. The exact location of this line still remains somewhat in question. The existence of a mixture of both liquid and gas in this region has been reported by Voorhees. More experimental data are desirable to determine the exact conditions and characteristics at these pressures and temperatures.

Standard Ton Chart for CO_2

The standard ton chart for CO_2 is built up from the best available data on CO_2 of both Europe and America. Many values have been recomputed and corrected, especially for the values of the constant quality and temperature lines. The high pressure incident to CO_2 refrigeration necessitates the inclusion of the volume of the liquid in determining values for constant volume lines in the region of the mixtures. In many available charts the values plotted are the volumes of the gas only. This procedure is permissible in low-pressure work since the relation of the gas volume to the liquid volume is so great, but with CO_2 it leads to a very appreciable error in plotted values.

The standard ton chart herewith presented shows the standard ton cycle ABCD in heavy outline.

Solution of Hydraulic Problems Made Easy

Graphical Solution of Manning's Equation for the Flow of Water in Open Channels, Pipes and Circular Conduits Flowing Full. By E. B. Strowger*

PROBLEMS relating to the flow of water both with open channels of uniform section and with closed conduits of uniform section can be and are usually solved by Manning's Equation. The formula may be

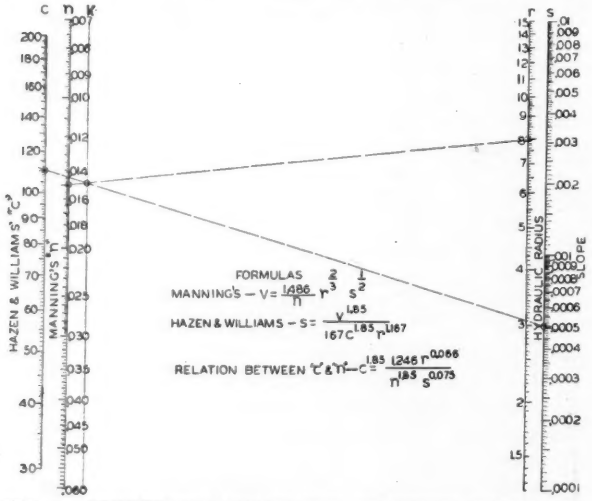


FIG. 1. CONVERSION CHART FOR CHANGING MANNING'S COEFFICIENT N TO THE COEFFICIENT C OF HAZEN AND WILLIAMS

rearranged so that it is readily applied to the special case of circular conduits flowing full, and an alignment diagram drawn using the four variables in the formula for application to circular conduits of various diameters.

This is done as follows. Manning's Equation is:

$$V = (1.486 \div n) \sqrt[3]{r^2}\ \sqrt{S} \qquad (1)$$

Where V = average vel. of water in ft. per sec.
n = coef. of roughness.
r = hydraulic radius.
and S = slope of water surface (loss of head in ft. divided by horizontal distance) in ft.

Equation (1) may be rewritten as:

$$Q = (0.4632 \div n) \sqrt[3]{D^8}\ \sqrt{S} \qquad (2)$$

Where Q = discharge in cu. ft. per sec.
D = diameter of conduit in ft.

Values of n for a number of different materials are given below:

Material	n
Cast iron	.011—.015
Wrought iron	.011—.015
Vitrified clay	.011—.017
Wood stave	.010—.013
Neat cement	.010—.013
Concrete pipe	.012—.016
Concrete lined tunnels	.012—.018
Glazed brick	.011—.015
Unglazed brick	.012—.017
Riveted and spiral steel pipe	.013—.017
Rock cut	.025—.045

Figure 2 gives an alignment diagram for the solution of Eq. 2, which for convenience has been split up into the two equations

$$Q = K \sqrt{S} \qquad (3)$$

$$\text{and } K = (0.4632 \div n) \sqrt[3]{D^8} \qquad (4)$$

Where K is a variable common to both equations.

*The Niagara Falls Power Co., Niagara Falls, N. Y.

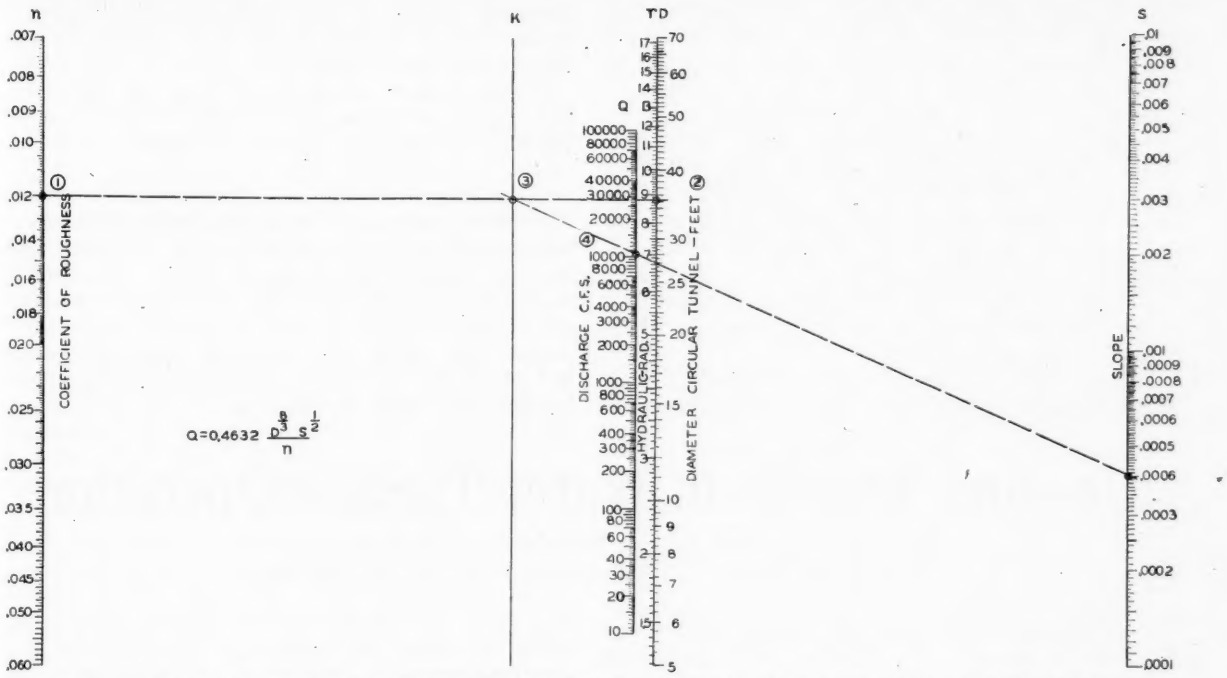


FIG. 2. CHART FOR SOLVING PROBLEMS DEALING WITH THE FLOW OF WATER IN CIRCULAR TUNNELS

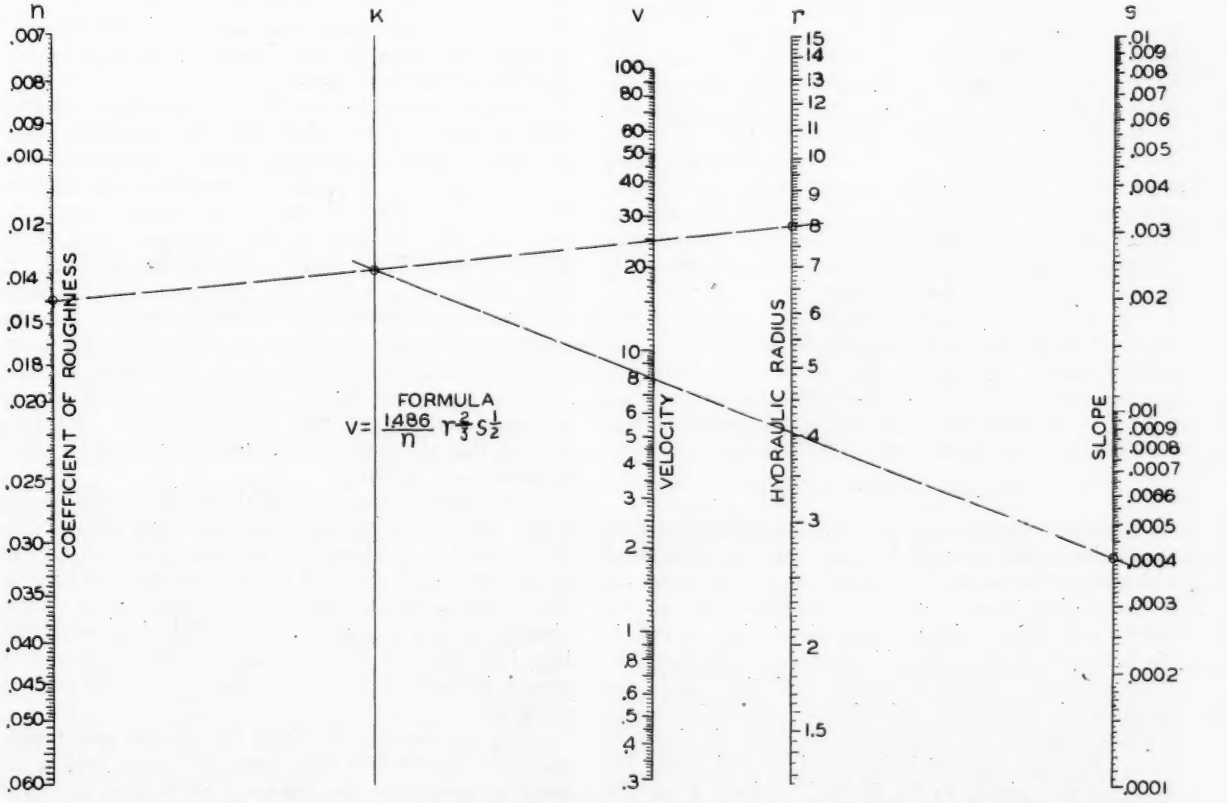


FIG. 3. CHART FOR THE SOLUTION OF PROBLEMS DEALING WITH THE FLOW OF WATER IN OPEN CHANNELS AND PIPES NOT FLOWING FULL

There are five vertical lines on Fig. 2, one for each variable in Eqs. 3 and 4; the K line, being common to the two equations, is used only as an index and requires no scale. The two sets of lines are indicated on the chart respectively by Q, K and S, and by K, D and n.

As an example find the slope S for a circular concrete tunnel 35 ft. in diameter carrying 10,000 cu. ft. of water per second with n taken as 0.0122. By the use of the chart a line is drawn from the point 0.0122 on the n scale to 35 on the D scale intersecting the K scale at 3. Connecting 3 and 10,000 on the Q scale and extending the line to the S scale, the value of S is found to be 0.0004 or 0.4 ft. per 1000. The chart was made specially for use with large conduits but may be used for calculating the losses in penstocks which have diameters down to 5 ft.

Figure 3 is an alignment chart solution of Manning's Equation in its original form with the quantities V and r appearing instead of the quantities Q and D. This chart may be used for the solution of Manning's Equation applied to open channels and to pipes not flowing full as well as to the more common case of circular pressure conduits.

Figure 1 gives an alignment chart for converting Manning's n to Hazen and Williams' C or vice versa. The relation between n and C is as follows:

$$C^{1.85} = (1.246\ r^{0.066}) \div (n^{1.85}\ S^{0.075}) \qquad (5)$$

Since S varies as V^2 in Manning's Equation but is proportional to $V^{1.85}$ in the Hazen and Williams' relation, the factor S still appears in Eq. 5. This chart is useful where a number of conversions are to be made at one time.

All three charts were originally made as tracings 26 in. by 36 in. from which photostat copies about 11 in. by 15 in. were made for office use.

Unusual Trouble in Water Turbine Operation

Boss Operator With U-Tube Beats Herr Doctor Ingenieures With Slide Rules 'n' Everything. By H. S. Schreiner

IN OVER 20 yr. contact with water turbines and their few ills, the one described in the following paragraphs takes the cake. In a plant of some size, not located within the United States, the unheard of condition of turbine output falling off appreciably as time goes on, was met. The plant design was quite normal, except that an old straight flared draft tube had to be taken out after rusting through due to bad water and, as a replacement, a concrete curved elbow tube was built in. The design of this new concrete tube was positively the last yelp in differential equations and the consulting engineer had the workmen chip out any portions which did not come right to templet, after the concrete had hardened. Anyhow, Europeans are much more painstaking with such matters and it doesn't take much imagination on our part to see the righteous indignation of an experienced American construction foreman on being told any such requirements, especially if he be a good orthodox Irishman.

To make a long story short, after they got everything all hooked up and were already running, the consulting engineer did a few slips with his slipstick and swelled out perceptibly when everything was buzzing along just about perfect. He packed up his brief case, said goodbye and figured out his bill on the way home.

Things Started to Pop

Next morning the operator was somewhat surprised to see the output some 15 kw. less with the same head and gate setting as the day before when everything was going so hotsytotsy. He took another look at the meters and then decided it was about time to call in his boss. What the boss said, we can't print here. In the first place, it was in Dutch and then again the operator was in Dutch with his boss, which last swore that the operator was drinking. We don't do that over here. The boss consulted the log sheet and found the operator was right, so he decided to keep a careful hourly watch.

Each successive hour the output went down a kilowatt or so and by that time the boss was getting hot under the collar. No turbine had ever acted like that to his knowledge, nor mine either, and nobody would dare to think that they had ever imagined anything like that to be possible. The head had stayed so closely constant all the while that they first thought the head gages were jammed, or stuck somehow, and after they went over all the instruments and checked everything up, they swore the place was bewitched. The boss got an idea. He shut the unit down a few minutes and then he started it up again.

Everything fine as sauerkraut; the output climbed back to where it was when they first started up and the crew looked at each other sort of queer like they had been gypped. But the log, kept very carefully, as close as one could read the meters, showed again the dropping off. So they let the unit run along for a full week and found that the power had dropped off about 100 kw. on a 2000-kw. machine. The big guys got the consulting engineer on the phone and he came along pretty soon and wondered what kind of a crazy crew they had running that place. He stayed there at the plant for a week himself, shutting down and starting up again and always the same old story. He then decided that the stuff was too deep for him so he called in some heavy artillery.

Over there a guy is a total nobody unless he has a few college degrees and is several kinds of a doctor. They decided to check up on everything, so all the meters were calibrated and a new start made on records. The heavy artillery had heard of some queer things already when a guy gets into the right kind of stimulant, but they felt sure that someone was pulling some smooth boloney on them and what was worse, showing them up.

They pronounced the draft tube design was mathematically correct and, that done, they were just as far away as ever from the answer. So it went on. The big guns went home and the place began to get some notoriety.

Boss Operator Heads Class

Being a pretty hard headed chap, the boss operator did some heavy thinking but while the heavy artillery was on hand he didn't dare open his face. He drilled some holes into the concrete walls of the draft tube and cemented in a pipe with a rubber hose and a "U" gage glass. Thus he could keep a record of the draft head and found that as time went on the head decreased. That meant that the effective head on the turbine was also decreasing and, by a few calculations, showed that the decrease in power was keeping step with the decreased head. That was a clue. He deduced from that, that air was leaking back into the tube and kept accumulating against the roof of the draft tube at the point where, in most draft tubes of the elbow type, the water flows back into the tube. When he shut down the turbine, he reasoned that he swept out all the accumulated air and the output was again normal. Then he found that, by putting flash boards on the crest of the downstream weir, he raised the tailwater level somewhat and the dropping off stopped!

So they found a way to raise the tailwater level permanently about a foot and this stopped the air leaking back into the draft tube. But the boss was not yet satisfied. He was losing power by the head being that much lower. Then he made a deflector of steel plate, sloping upwards toward the draft tube discharge and fitted the upstream end to a curve and anchored it to the concrete, so the air could not come back into the draft tube. Then, after lowering the tailrace level to where it originally had been, he was elated to find that his reasoning had been correct and the dropping off in output stopped.

If that doesn't take the cake, tell us one that does. The writer earnestly vouches for the truth of the main facts of the above story, without any secret evasion of mind whatever. He has heard of only one similar case elsewhere, so it's surely worth passing along to the operating fraternity as real dope.

Belgian High-Pressure Steam Power Station

AS LONG AGO as 1923 the Compagnie des Centrales Electriques en Flandres ordered from the Brown Boveri Co. of Baden, Switzerland, a 1700-kw. turbine designed to work with steam at an absolute pressure of 725 lb. per sq. in. and at a temperature of 442 deg. C., the highest pressure employed in Europe up to that time. The results given by the set proved so satisfactory that in 1927 an order was placed with the same company for a second turbine to work with steam at the same pressure and temperature but having normal and maximum capacities of 6600 and 8000 kw. The two turbines work with a back pressure of about 370 lb., the exhaust steam being employed to run the older condensing-type turbines. To meet the requirements of the new turbines the boiler installation was altered from 327 lb. per sq. in. pressure and 325 deg. C. temperature to 810 lb. and 450 deg. C.

Owing to the increasing demand for electric power supply, it became necessary last year to arrange for an extension of the generating plant at Langebrugge, an order being placed, again with the same builders, for a turbine capable of developing 20,000-25,000 kw. and of working with steam at 725 lb. and 442 deg. C. The turbine which is the largest so far to be constructed for so high a working pressure, is of the three-cylinder type and is designed to run at 3000 r.p.m. Special attention has been devoted in the design to meet the particular requirements especially in the low-pressure section of the machine. The difference in the temperature in each stage is very small, reaching only 150 deg. C. in the high-pressure section.

The shaft of the high-pressure rotor is rigidly coupled to that of the medium-pressure section, while the rotors of the medium and low-pressure sections are connected by a semi-flexible coupling. The fixed connection between the two first stages is provided with a thrust bearing, the two casings being thus free to expand separately without imposing any strain on each other. The various component parts are all so designed as to secure uniform heating.

The rotating portion of the high-pressure stage comprises a wheel with two crowns with impulse and reaction blades. The steam distribution system is of the Brown-Boveri standard type. For the maximum economic output of 20,000 kw., steam is admitted above the impulse wheel which works with total injection at that power. For higher outputs steam is admitted directly to the reaction blades.

Two graduated rotors, each half rotor embracing five disks with one or two crowns of reaction blades, are used in the low-pressure section. As there is no intermediate re-heating of the steam, the later stages of operation in the low-pressure section are associated with very wet steam, to deal with which a special condenser water exhausting device is provided. Below the third disk of each half rotor is a canal in which water, by centrifugal action, is collected, thence transferred with the steam used for heating purposes in the feedwater heater.

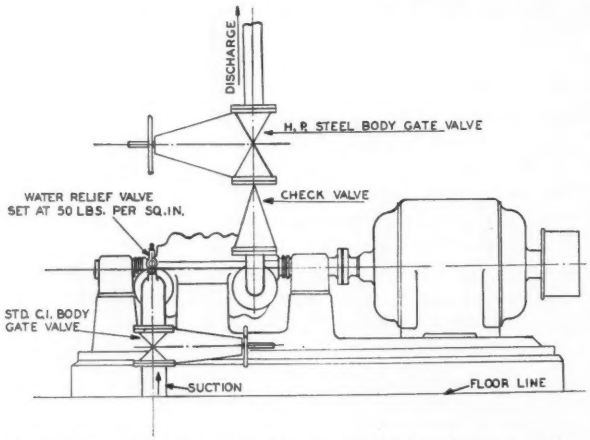
Directly coupled to the turbine is a 25,000-kw., 12,000-v., three-phase generator which operates at a power factor of 0.80. The overall length of the set is nearly 50 ft. and as it had to be installed in a room only 60 ft. in width, the exciter and the air cooling fan had to be mounted above the alternator, they being separately driven by a small auxiliary turbine.

As a result of the high pressure, it is claimed for the Langebrugge plant that it is now converting into electric power 23 per cent of the calorific energy of coal as against only 14 per cent in the case of generating stations working at a pressure of 284 lb. per sq. in. The chief engineer of the station is, however, still seeking to make further progress, work being now in hand on the installation of a Benson boiler designed to produce 100 t. of steam per hour at a pressure of 3200 lb. per sq. in.

Although Dr. Diesel's original patent, dated 1892, related primarily to an engine for utilizing coal dust, a second claim in the patent covered the use of liquid fuels by use of a spray valve but not by air injection. These engines were to be started by some other explosive and although it is not definitely known why the original engine never turned over beyond its initial stroke, it is thought that it was wrecked by the starting explosive.

Relief Valve Protects Pump Casing and Piping

RAPID INCREASE in steam pressures, with the accompanying increase in pressures in boiler feed lines, which has taken place during the last few years, has made



RELIEF VALVE PROTECTS BOILER FEED PUMP SUCTION CASING AND PIPING FROM BOILER FEED HEADER PRESSURE WHEN DISCHARGE VALVES LEAK AND SUCTION VALVE REMAINS TIGHT

the protection of low-pressure piping and equipment from excess pressures an important problem.

Any high-pressure pump, such as a boiler feed pump, forms a connection between high and low-pressure piping. The lower stages of high-pressure centrifugal pumps and the suction piping are not designed to withstand full discharge pressure. When the pump is shut down and other pumps are maintaining the pressure in the header to which the discharge of the pump is connected, it is possible that slight leaks in the discharge valves may allow considerable pressure to build up throughout the pump casing and piping between the pump and the first valve in the suction line. If this suction valve is absolutely tight, under these conditions these parts will be subjected to the full header pressure, which is probably several times the pressure they were designed to withstand. This usually causes trouble with joints and stuffing boxes, even though serious rupture does not result. Excess pressure, under the above conditions will be prevented by the installation of a small water relief valve between the pump suction and the first valve in the suction piping, as shown in the attached sketch. It is not desirable to pipe away the discharge of this relief valve, because the amount discharged at any one time is not enough to be a menace to safety and each opening of the relief valve is an indication to the operator that the discharge valves are leaking and should be repaired at the earliest opportunity.

Some operators prefer to use a small globe valve in place of the relief valve, this valve being opened every time the suction valve is closed, but this method does not afford positive protection because it is not automatic. The relief valve need not be large. The writer usually uses a one-inch valve set to open at a pressure of 50 lb. per sq. in., where the normal suction pressure does not exceed 50 ft. of water and 125-lb. standard fittings and valves are used.

Kansas City, Mo. C. A. BUTLER, JR.

Boiler Tests Should Include Calorimeter Readings

BOILER TESTS are usually taken with great care and measurements taken to the fourth and fifth decimal place in spite of the fact that many of them are of questionable accuracy and the test code states definitely that it is questionable whether an accuracy of 3 per cent can be expected.

As a rule, the coal measurements are quite accurate, although water measurements are only too often taken from meters which are not in adjustment either through carelessness or ignorance. It is surprising how results of recording and indicating instruments are accepted blindly without checking. Temperatures are usually taken fairly close because the average thermometer is not easily put far out of adjustment.

In gas measurements, however, there is no certainty that the results are right even though the readings are correct. There is much stratification of gases at the exit and this stratification is not the same at all rates of firing. Not many engineers take the trouble to make traverses across the entire width of the breeching opening to determine where average conditions are and still fewer take the trouble to determine what effect the damper position has on the readings. This stratification applies to the exit gas temperature as well as to the gas analysis.

Few engineers bother to take calorimeter readings to determine the moisture or quality of the steam. This point came up in a discussion among some engineers

recently in connection with some baffling changes. Tests before the change showed an equivalent evaporation of 6.60 lb. of water per pound of coal with 10.5 per cent CO_2 and an exit gas temperature of 590 deg. F. Later tests showed an evaporation of 7.10 lb. with a CO_2 content of 10.2 per cent and a gas temperature of 610 deg. F. The first test was at 160 per cent rating and the second at 195 per cent rating.

It was assumed that the 0.50 lb. additional evaporation was due to the change whereas both the CO_2 and exit gas temperature indicate that the efficiency was actually lower in the second stage than in the first. The explanation, of course, lies in the quality of the steam. The boiler must have been throwing considerably more water. Dropping the quality from say 97 to 90 per cent would have accounted for the increase.

No boiler test is complete without calorimeter tests. It has been pretty well established that even steam carrying a rather high superheat may have some moisture in it and in a boiler test a pound of water carried out as water shows on the boiler feed meter just as big as a pound going out as steam.

Los Angeles, Calif. J. J. ALDEN.

Cooling Engine Oil

OUR ENGINE is located in quite a hot place, especially during the summer months, and our lubricating oil for the bearing, crossheads and eccentrics gets very hot after a few hours' run. This hot oil would return to the Skinner oil filter and reservoir tank and then the pump would pick it up with just about 8 deg. temperature difference between the returning oil and the oil supplied back to the bearings. Under our present system, we drain the reservoir tank once every 24 hr. and run this oil through an independent filter and then fill the reservoir tank with cool filtered oil. I priced some heat exchangers that we could use but the price of this equipment was too high, so I finally installed a device on the engine that is working very satisfactorily.

I purchased a fuel oil heater, the construction of which is as follows: An 8 by 40-in. black pipe is used as a casing around ¾-in. coils which are made up of pipe and return bends. This casing has a welded head at one end and a flange welded on the other end has a header bolted to it. The two leads coming through this header are fitted with regular stuffing boxes. This cooler cost me just one-third the price of the lowest priced heat exchanger.

Overflow cooling water coming from the ice machine cylinder is passed through ¾-in. pipe and runs for 7 ft. through the freezing tank and then through the oil cooler coils emptying into a small open hot well where it mixes with the returns from the hot water heaters and is then pumped into the main feed tank or hotwell.

This oil cooler is located next to the Skinner filter and reservoir tank, the oil returning from the engine passing successively through the filter, reservoir tank and cooler. The oil pump of the engine draws its supply from the header of the cooler and pumps it through the lubricating system of the engine. The temperature of the oil entering the oil cooler is 121 deg., while the temperature of the oil which has passed through the cooler is between 60 and 65 deg.

Los Angeles, Calif. LAWRENCE B. BROWN.

Improper Bleeder Installation Causes Erratic Turbine Operation

SOME TIME AGO, an odd situation arose at a neighboring factory in connection with the installation of a new turbine, almost but not quite identical with one already installed. The plant had gradually developed in a rambling sort of way, without any competent engineering direction but largely upon the advice and recommendation of the old engineer who was a good practical man but not any too well informed about the operation of turbines, which he rather disliked because they displaced his old engines which he understood.

Pressure from above and good salesmanship finally sold him a turbine, however, which he installed in a creditable manner in the place vacated by one of the old engines as shown at A in Fig. 1. The turbine was bled at one stage for heating the feedwater and the condenser was set at right angles. Bleeder connection to the open feedwater heater was made as indicated by the heavy black line.

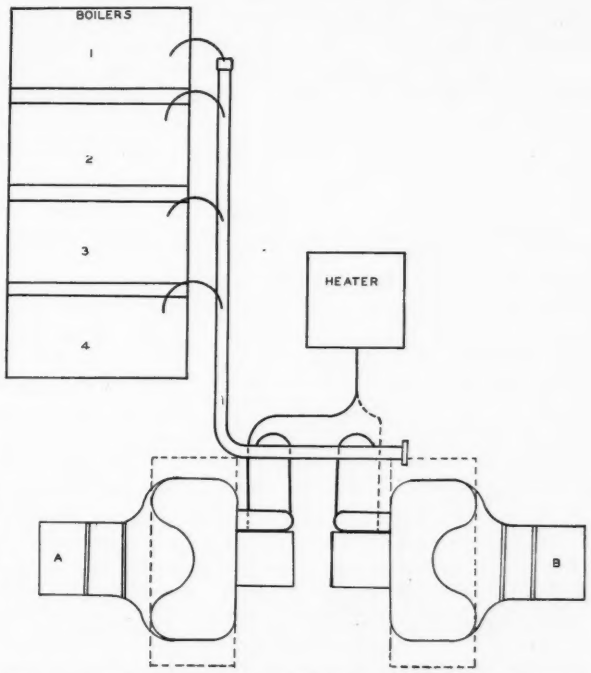


FIG. 1. INSTALLATION OF STEAM TURBINES AS ORIGINALLY MADE

They were troubled with a little more corrosion than usual but apparently it was a successful installation and when the time came to increase the capacity again, another turbine was installed as shown at B, Fig. 1. This simplified the piping somewhat and made it possible to get in the turbine without taking out any of the old engines which were still operated when their exhaust could be used for heating.

As before, the new turbine was set by the engineer without outside help and the extraction connection joined into the old line by removing an elbow and replacing it with a tee, as shown by the dotted line. The new turbine was about the same as the old one but, because of a much lower price, it had been bought from a different manufacturer.

Before long, trouble developed. It seemed that, not wishing to work the new turbine too hard at first, the old machine was made to carry most of the load, while the new one carried only the peaks and what little load was left over. Every once in a while the new machine would take all the load, speed up until the emergency governor tripped and then stop. The governor was inspected, reset and adjusted several times but the trouble was not remedied. Finally one of the manufacturer's service men was called in, much to the mortification of the old chief. Being a diplomatic man, however, the service man soon straightened that out by telling of some of the big plants he visited every year or two to inspect the machines and adjust them. The old man, who never had had a service man in the place before, could not understand this at first but finally ended up by feeling that he was quite up to date and doing the right thing to call for help.

The service man discovered that the new machine had a slightly lower extraction pressure than the old

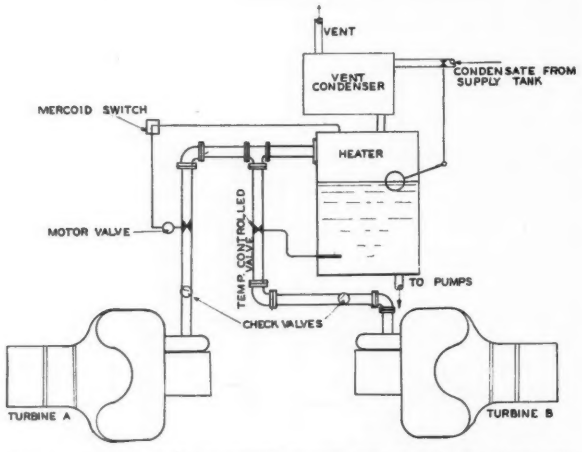


FIG. 2. CHANGED CONNECTIONS TO HEATER AND INSTALLATION OF CHECK AND CONTROLLING VALVES OVERCOME ERRATIC ACTION OF TURBINES

one and this difference had been exaggerated by carrying a heavy load on the old machine and a light load on the new machine. Both turbines had been installed without check or non-return valves between the turbine and heater so that low-pressure steam from the old turbine was bypassed to the new one. As this steam was not under control of the governor, it speeded up the new turbine while the other machine, heavily loaded and losing part of its low pressure steam, tended to slow down, causing its governor to open up wide and increase the unbalancing of pressure.

This was soon remedied by the installation of proper valves as indicated in Fig. 2. During the course of his investigations, the service man discovered that the vent from the feedwater heater was partly plugged up by a well-weighted piece of board which prevented free egress of air. It seemed that the bleeder pressure was just about atmospheric and, as the load varied, the pressure would range from slightly above to slightly below atmospheric so that sometimes the vent would blow out some steam, while occasionally it would suck in some air, which in turn interfered with the vacuum in the condenser. One day, the engineer noticed this so he covered the vent. Fortunately it was not tight enough to stop the exhaust of air completely but the water temperatures were low and undoubtedly the upper part of the heater was filled with air most of the time, which was responsible for the rapid corrosion caused by the large amount of air absorbed.

Because the new turbine had a considerably better water rate than the old one, the service man recommended that this machine carry the steady load and let the old machine carry the peaks. Before he left, he made a sketch, Fig. 2, showing how best to handle the steam. This required the installation of a vent condenser on the open heater. Condensate and makeup are fed through this condenser on the way to the heater and condenses the steam that would otherwise escape. At full load, the extraction pressure is slightly above atmosphere. Steam flow from the extraction outlet of the new turbine is regulated by the pressure in the heater. A small mercoid switch and motor-operated valve are arranged so that the pressure will not exceed one-half pound. If it reaches this pressure, the valve is closed. The line from the new turbine has a temperature controlled valve which opens only when the temperature of the feedwater falls below 200 deg. F.

This new arrangement operates nicely. The new turbine with the higher efficiency carries most of the load and heats most of the water. At heavy loads when the one machine cannot supply enough steam to maintain the desired temperature, the valve connecting the old turbine is opened and steam is taken from both of them. This works well because the extraction pressure of the old machine is slightly higher anyway and, as it is used only when carrying a good load, there is always sufficient steam to bring the temperature up to 212 deg. and still require some throttling. When the temperature goes above this, the old turbine is cut off and the new one supplies all the steam.

Brooklyn, N. Y. F. PAUL.

Pyrometer Installation

MODERN BOILER PLANTS should have reliable pyrometer installations to show the temperatures prevailing at different parts of the boilers. Whenever possible, the pyrometer wiring should be protected by conduit, which should be carefully installed and free from internal burrs with all bends made of as large a radius as possible. It is advisable to install the conduit completely first and then draw the wires in.

Open wiring should be avoided wherever possible but, where unavoidable, the cables should be kept away from moisture and other wiring, never within one foot of a circuit having a potential of over 100 v., or induced currents may result which will affect the instrument readings.

All joints in the wiring must be well soldered and then fully insulated. The instruments should be mounted so as to be free from vibration and located in a temperature not exceeding 150 deg. F. All instruments should be fixed at a height which will be approximately on a level with the reader's eyes. In all places where the temperature exceeds 300 deg. F., asbestos or other slow burning wire covering should be used.

All connections, both to the instruments and to the thermo-couples, should be carefully made. They should be perfectly clean and the nuts well tightened up and secured by check nuts. Incorrect readings at the in-

struments are often due to dirty or loose contacts. Recording instruments should be fixed perfectly vertical and level and in as dust proof a position as possible, as sticking of the pointer is often brought about by incorrect setting of the instrument or dust getting into the case.

Brentford, England. W. E. WARNER.

Reshaping Cutting Tool on Pipe Threading Machine

ABOUT A year ago the employes in the power plant persuaded the management to install a pipe threading machine of well-known make. The industry had been running along for 30 yr. and to convince the powers that be wasn't so easy. The leading arguments used in favor of the machine were that it would reduce labor cost and also show a saving in the making of nipples. After the machine was installed, the arguments proved sound.

This machine was equipped with a cutting tool for cutting the pipe in desired lengths without bevelling the edge. This tool cut a shaving about ¼ in. width and also left a ring of the shaving on the piece of pipe that dropped from the machine.

In making 2 and 3-in. nipples, we used a home-made chuck, constructed of a coupling and a piece of pipe with a long thread to cut the thread on the bold end of the nipple. As the machine ran with the thread, when using the cutting tool, we could not cut the shaving off without running the nipple out of the chuck, jamming the machine and breaking the tool.

We found by grinding the tool 1/16 in. lower on the inside of the cutting edge, the outside edge of the tool would cut the shaving so that the piece of pipe extending from the machine would drop off clean cut. The shaving remaining on the piece of pipe in the machine could, of course, then be easily removed by the cutting tool. Yes, it was very simple but it took us a year to find it out.

Anderson, Ind. GEORGE S. BILLMAN.

Coal and Ash Handling Made Easier

AN ENGINEER who was running an engine and doing his own firing in a small flour mill found his employers glad to have him "slick-up" around and in the mill, whenever opportunity offered. After one winter of digging coal out of a snow-covered pile and dumping ashes onto a wind swept pile the engineer obtained permission to construct closed bins into which coal could be dumped from a gondola car. He was also able to rig up another shed, the mill being upon a hillside, wherein ashes could be dumped into a sort of hopper with bottom gates, under which a cart could be backed and the hopper of ashes, emptied directly into the cart whenever a cart load of ashes had accumulated. It was further arranged that the cart be kept under the ash-hopper nights and at other times when not in use, thus, ashes could be dumped from the hopper at a moment's notice.

After the coal shed had been built, the engineer obtained possession of a lot of 2-in. industrial car rails and their fittings, also the metal work of two push cars, all of which had been through a fire and were somewhat bent and twisted.

Two pieces of I-beam were fastened together with just room enough between them for a jackscrew and a rail. With the jackscrew fastened, upside down, under the upper I-beam and brought down upon a rail with a couple of pieces of flat steel between the rail and the lower I-beam, the engineer "played chiropractor" with the bent rails and adjusted them until they were straight.

Two lines of track were then laid from the coal shed, terminating one in front of each boiler. Another track was laid from the ash-dump and connected by means of a pair of switches, with each of the coal tracks.

The metal work of the push cars was then carefully overhauled and the cars rebuilt, two of them being plain push cars with fixed boards on three sides and with one end of the car which hinged so as to be unfastened and let down when coal was being taken from the cars. The ash car was made two-story with an ash box from which the contents could be dumped, without any shovelling, into the ash-hopper.

This coal and ash arrangement proved ideal in the hilly place where it was located.

Indianapolis, Ind. JAMES F. HOBART.

First-Aid Instructions in Power Plants

STATIONARY POWER plant owners could take a valuable lesson from the Bell Telephone Co. of Canada. Practically all their outside and repair men are compelled to take lessons, which are supplied them free of cost over a period of several years, in connection with First-Aid in all its branches. Thousands of these workers are always ready, capable, and instructed to give first-aid, free of charge to any person, whether a company employee or not. All the workers carry small first-aid outfits.

The number of stationary power plant workers who are capable of rendering first-aid in an efficient manner in an emergency are comparatively few. Even if some of them have the necessary knowledge, they are likely to be handicapped by lack of supplies. I have personal knowledge of power plants where not even a roll of cotton bandages or a roll of absorbent cotton is kept on hand. All electric power workers should be instructed in artificial respiration, which instruction is easy to impart even to comparatively ignorant laborers, with a little patience, an illustrated chart in colors and a capable instructor. A first-aid kit for power plant use should contain in separate bottles, spirits of ammonia, picric acid, peroxide of hydrogen, sweet oil, also such items as unguentine, adhesive tape, absorbent cotton, a pair of scissors, a pair of tongue pliers, at least one towel, a small book of emergency treatment instructions, and a plainly printed notice warning all employees who failed to study the instructions that they were liable to be discharged for failing to do so. At the cost of a few cents each, such a book of instructions can be supplied every employee. With a little knowledge of first-aid much suffering can be prevented and often a life saved. Even some of the large power plants are very lax in spreading first-aid knowledge among their employees.

Toronto, Can. JAMES E. NOBLE.

DOLLARS SAVED by employing poor firemen and engineers do not remain long in the owner's pocket.

Questions and Answers

Action of Superheated Steam

WE HAVE a compound vertical condensing marine engine. The boiler pressure is 225 lb. per sq. in. but is reduced to 175 lb. per sq. in. at the throttle. The high-pressure cylinder is 22½ in. and the low-pressure cylinder 50 in. diameter. The stroke is 30 in. The high-pressure steam valve cuts off 21⅞ in. on the down stroke and 20 in. on the up stroke. The lead at the top is ¼ in. and at the bottom ⅜ in. The low-pressure steam valve cuts off 20⅞ in. on the down stroke and 19¼ in. on the up stroke. The top lead of this cylinder is 5/16 in. and at the bottom it is ½ in. The average speed of the engine is about 130 r.p.m.

We need answers to the following questions:

1. Is steam superheated when expanded through a reducing valve?

2. Why do the valves cut off later on the down stroke than on the up stroke?

A. Steam is superheated when it is passed through a reducing valve, if it was saturated before it reached the valve, since at the lower pressure, less heat is required for a pound of saturated steam and no heat is lost in reducing the pressure.

2. The points of cutoff on the two sides of a piston are changed so as to produce indicator diagrams of equal size on each side in which case the work done on each side would be equal. Change in point of cutoff is made necessary because the piston rod reduces the effective area of the piston on the lower side.

The point of cutoff should therefore be later on the piston rod side which, in the case of a vertical engine, would be on the up stroke rather than on the down stroke as you have stated it in your question.

In a vertical engine, the weight of the reciprocating parts, which include the piston, piston rod, crosshead and two-thirds of the weight of the connecting rod, would also have to be compensated for since they are pushed up by the steam; the work thus done must be subtracted from the net work of that stroke, while during the down stroke their weights add to the net work, hence the work done due to this weight should be added to the net work of the down stroke.

Calculations for Transmission Line

WE HAVE RECENTLY contracted with a spinning and knitting mill for their power requirements, the total connected load being 1500 hp. in motors and their lighting 75 kw. We expect to furnish them with 440-v., 60-cycle, 3-phase current for power and 200-v., single-phase current for lighting. In our plant we generate at 2400 v. and the distance from their plant to ours is 2 mi.

I would like for you to advise me your recommendations on the following: transmission voltage, size of copper conductor, separation of conductors, size and number of transformer. What would you consider a fair demand to figure on for a mill of this type and size? I have heard indirectly that 80 per cent would be a fair figure or, in other words, that their maximum power demand would be 1200 hp. but have had no way to check this up.

I would like to keep my line losses down to 5 per cent if possible, not including transformers.

Would you consider 2400-v. transmission feasible?

B. S. R.

A. In considering a proper demand factor for a plant of this kind, we believe that the figure of 80 per cent mentioned in your letter, is about correct. Data on demand factors for various types of industrial plants are rather scarce and a careful search through a number of published books on the subject of transmission line design has failed to disclose any definite figures which we could use.

We have in our files in this office, however, some unpublished data on transmission line work, and we find in this data that for woolen mills a demand factor of 80 per cent is about average. Textile plants in general are given as about 65 per cent. So we believe that the assumption of an 80 per cent demand factor will provide you with a line of ample size to carry the maximum load.

As stated in your letter, the load consists of 1500 hp. in motors and 75 kw. for lighting. Converting the 1500 horsepower to kilowatts, we obtain a total connected load of

$$1500 \times 0.746 + 75, \text{ or } 1194 \text{ kw.}$$

Assuming a power factor of 80 per cent, the total connected load will be

$$1194 \div 0.8, \text{ or } 1492 \text{ kv-a.}$$

With an 80 per cent demand factor, the total kv-a. to be transmitted at any time will be

$$1492 \times 0.8, \text{ or } 1194 \text{ kv-a.}$$

Having determined the load, the next thing to consider is the transmission voltage. Transmission voltages are usually determined by means of Kelvin's law, and in the case of a short line such as yours, we can apply the ordinary "rule of thumb" of 1000 v. per mile, which in the case of your line 2 mi. long, yields 2000 v. This is fortunate since it will enable you to transmit directly at the voltage at which you are generating, namely 2400 v. The use of this voltage will eliminate the necessity for step-up transformers at the sending end, eliminating the transformer losses and reducing the cost of equipment considerably.

The size of conductor for the line is best determined by means of tables contained in Wm. Nesbit's book—"Electrical Characteristics of Transmission Circuits."

Using these tables, we find that to deliver 1194 kv-a.

over a distance of 2 mi. for a load power factor of 80 per cent and a 5 per cent I^2 R, a copper conductor of 700,000 circular mils cross-section would be required. This is for a 5 per cent I^2 R loss, as specified in your letter. This, as you will note, demands a conductor of considerable cross section, and if you are willing to tolerate an I^2 R loss of say, twice that amount, the size of the conductor could be cut to 250,000 circular mils.

It is in the selection of the proper size of conductor that Kelvin's law referred to above, is used, and it is merely a question of balancing the extra cost of the heavier conductor by the increased revenue due to the lower losses of such a conductor.

Without knowing the prices which you are to pay for copper, it is impossible for us to determine the most economical size of line.

As to the size and number of transformers required for this transmission line, this will depend considerably upon how the load is concentrated at the receiving end. If the motors are scattered over a comparatively large area, it will perhaps be best to install individual step-down transformers for a number of separate groups. If all the motors are grouped close together, it will be best to install one bank of three-phase transformers to take care of the entire power load, and another bank for the lighting load.

In the latter case, assuming an efficiency of 90 per cent for the transformers, a bank with a total rated capacity of 1325 kv-a. would be required.

The calculation of the proper constants for the transmission line depends upon many conditions and in this case, since we were forced to make a number of assumptions, the figures given in this letter must be considered more or less as approximate.

We believe that we have figured the constants on the safe side, and we feel sure that if the line is constructed using the 700,000 circular mil cable, you will have no difficulty in carrying the maximum power.

Efficiency Varies with Size of Lamp

IF A 110-V., 20-candlepower Mazda lamp takes 25 watts, how many watts will 2 candlepower 12-v. lamp take? Is there a formula or is it necessary to obtain the rating from a lamp company? C. E. W.

A. There is no simple formula by which the rating of a given lamp can be calculated when the rating of another size lamp is given. Generally the power consumed is approximately one watt per candlepower. The efficiency enters into such a calculation and the efficiency varies with different wattage lamps for a given length of design life.

A 2-candlepower, 12-v. automobile lamp will require approximately 2¾ watts with a rated life of 200 hr. The standard line of lamps is rated at 1000 hr. and the light output of the various sizes is shown in the table below.

110-VOLT, 1000-HOUR LIFE STANDARD LAMPS

Watt	Lumens	Mean Candlepower
15	132	11.5
25	242	19.2
40	412	32.8
50	540	43
60	690	54.9
100	1360	108

You will note above that there is a column showing lumens of light output. This column is given because we generally speak of the light output in lumens on practically all types of lamps with the exception of automobile lamps. A lumen is the rating of the total light output of a lamp and there are 12.57 lumens for each mean candlepower.

Duplex Pump Capacity

HOW MANY GALLONS of water will an 8 and 5 by 10-in., double-acting, duplex pump deliver when operating at 100 strokes a minute (each cylinder) allowing 3 sq. in. for the piston rod area? What would be the formula if this were a single-acting pump? A. J. F.

A. The area of a 5-in. dia. plunger is 19.63 sq. in. and this multiplied by the stroke, 10-in., equals 196.3 cu. in. which is the piston displacement. Since each piston makes 100 strokes per min. and, since the pump has two cylinders, the capacity discharged per min. from the head end, neglecting slip, would be $2 \times 50 \times 196.3 = 19{,}630$ cu. in.

In order to obtain the piston displacement on the piston rod side, the area of the piston rod must be deducted from the area of the piston hence we have $(19.63 - 3) \times 10 \times 2 \times 50 = 16{,}630$ which is the piston displacement in cubic inches of the piston rod side; therefore the entire capacity at 100 strokes per min. will be $19{,}630 + 16{,}630 = 36{,}260$ cu. in. and, as there are 231 cu. in. in a gallon, the number of gallons pumped, disregarding slip, will be $36{,}260 \div 231 = 157$ gal. per min.

If the pump were single acting, it would discharge from the head end only and no allowance would be required for the area of the piston rod, hence we should have $19{,}630 \div 231 = 85$ gal. per min.

Function of Boiler Water Legs

WHAT IS the purpose of the water-legs on a Heine boiler? V. P. K.

A. The principal purpose of the water-legs or headers of a Heine boiler is to form a connection between the tubes and drum of the boiler in order to provide proper water circulation. They also act to support the boiler. The front end is fixed to the brick setting; the rear end rests on rollers bearings on iron plates, thus permitting expansion and contraction due to heat.

WITH PULVERIZED coal fires, coals high in fixed carbon give better results if only part of the air required for combustion is used as primary air and mixed with the coal. The smaller percentage of primary air forms a richer mixture with the volatile gases giving quicker combustion and a steadier flame. If too much air is used, the mixture is lean, ignition starts far from the burner and the flame may blow itself out.

With more volatile coal, a larger percentage of primary air may be used. If only a small amount of primary air is used, there will not be sufficient oxygen to burn the volatile completely and it will break down, leaving soot suspended in the gases and cause a long smoky flame. With very high volatile coals, all of the air needed for combustion can be supplied with the coal.

Editorial Comment

What the N.A.P.E. Will Find in Dixie

As this issue goes to press, the National Association of Power Engineers is preparing for its 47th Annual Convention at Chattanooga, Tenn.

It goes without saying that the city will accord the association a most enthusiastic display of its famed hospitality. To those members of the association who live and work in the South, this hospitality will be no new thing. But members from other parts of the country are going to be mightily surprised and pleased at what they find there.

They will find in Tennessee and its neighboring states, Alabama and the Carolinas, a new industrial empire, the future development of which is destined to have a profound effect on our economic development. They will find a beautiful country, prosperous and progressive far beyond the ideas of most people outside its borders. They will find a district rich in historical associations. Finally, they will feel perhaps more strongly than ever the great influence that the power plant industry, of which they are a part, has had in the development of this rich empire.

Visits to some of the industrial power plants of the type described in this issue as well as to the great hydroelectric and steam plant developments of the public utilities should furnish new ideas to every member of the N. A. P. E. and increase his pride in his chosen calling. Add to this technical stimulation the enjoyment of a section noted for its beautiful scenery, its historical background and its hospitable people and you have a combination that will make the 47th Convention a memorable one for every N. A. P. E. member who attends it.

High Temperatures

Wherever the ultimate development of the heat cycle may lead us, present indications are that, for the first time in many years, European and American efforts toward higher efficiencies are more or less along the same lines.

With the exception of a few extreme pressure developments like the Benson, European investigators have based their hopes on higher temperatures rather than higher pressures. From a purely theoretical standpoint the possibilities are much greater.

Americans, on the other hand, pushed for immediate increases in economy and large capacity units, also faced with uncertainty regarding the properties of metals at high temperatures, took the only possible course which offered immediate relief and developed equipment for higher pressures at an assumed safe upper temperature of 700 to 750 deg. F.

With such a development, problems were numerous but purely mechanical. Practical application of the 600-lb. reheat cycle, notably at Crawford, Philo and Columbia, has been instrumental in demonstrating the benefits of higher pressures but this pressure range, because of its attendant complications has never been popular and is probably due to be displaced entirely by the somewhat questionable thermal economy but decided financial economy and mechanical advantage of the 1200 to 1400-lb. cycle.

Investigations of properties of metals at high temperatures have been carried along steadily but short time tests are still subject to controversy and such long time tests, extending over periods of one or two years, as have been made have not clarified the matter. Valve manufacturers are ready to stand behind their equipment for temperatures up to 1000 deg. which is no longer uncommon in the oil industry.

Having reached the ultimate development of high pressures, it is but natural that American investigators are now following the lead of Europeans and turning toward higher temperatures as a means of increasing economy of power generation. An increase from 750 to 1000 deg. F. offers practically the same heat economy as one stage of reheating but with decidedly less complications.

If the practical experiment being carried on at the 1000-deg. installation of the Detroit Edison Co. is successful, as we have every reason to believe it will be, it will open up a new era of power plant development, which taken alone will be remarkable but which in combination with binary vapor systems may cut the present heat rate to half its present value.

Higher Steam Pressures and the Operating Engineer

With steam pressures of 400 lb. and above, the men in charge of operation are confronted with many problems that are entirely different from those met in plants where the maximum pressure is 250 lb. Not only is more material added in the design of equipment to make it stronger, but, in many cases, the principles of the design have been changed to meet high-pressure demands and, due to the high temperatures encountered, the materials used are vastly different. The change from low to high pressure is taking place gradually, probably just as rapidly as the industry is able to develop safe equipment and train men to operate it.

Unquestionably the man who has been trained in a low-pressure plant will find his difficulties multiplied when he takes charge of a plant operating at 600 to 1200 lb.; everything in the plant is more sensitive; adjustments must be made with greater care; pressure and temperature variations that are allowable in the low-pressure plant would be extremely dangerous in one using high pressure; greater care must be used in the handling of valves; leaks at joints and past packing cannot be tolerated; insulation must be watched to prevent not only heat waste but also fire hazard. If the

plant is to take full advantage of high pressure, a thorough understanding of the heat cycle by the men in charge is essential and this, in most cases, does not resemble that of the low-pressure plant, either in pressures or temperatures and only slightly in equipment.

High-pressure boilers must be operated with extreme care for they are maintained at temperatures close to the yield point. Hot spots throughout the setting must, therefore, be avoided. The dangers from the accumulation of scale in boilers and caustic embrittlement are greatly increased with high pressures. Feedwater treatment must, therefore, be studied and extreme care used to see that the water is made as pure as possible.

All these conditions call for auxiliary equipment of the highest type, the details of which have been worked out especially for the service. Water columns, feedwater regulators, safety valves and blowoff systems have necessarily been redesigned; combustion control, feed pumping equipment, feedwater heaters, economizers and air preheaters have all undergone changes in design to fit them for high-pressure plants. With the more exacting operating conditions has also come the need for more accurate instruments and additional instruments that have been considered nonessential in plants using low-pressure steam. Especially needed are those to keep the operators informed on temperature conditions throughout the boiler setting.

To play his part in the development of the power industry, the operating engineer will be required to familiarize himself not only with the mechanical construction and adjustments of the equipment but with the physics, chemistry and thermodynamics underlying the operation of the plant. This is a challenge to the men at work in the power plants of today. Higher steam pressures require men with higher education, greater skill, more dependability and unquestioned integrity.

Off Duty

Those of us who in our younger days were victims of cod liver oil have good reason for harboring feelings unfavorable to the vitamin "D." The vitamin "D" is the "something" in foods which enables us, properly, to assimilate calcium and phosphorus and therefore is beneficial in the prevention and cure of rickets. Now, this vitamin "D" or whatever it is that is beneficial is present to a high degree in cod liver oil and for this reason it was fed to us in large nauseating doses when we were young. Not having a proper appreciation of its anti-rachitic qualities at that time we naturally developed a violent distaste for cod liver oil. And today, even though we may be aware of its beneficial qualities the distaste remains.

Ever since scientists first discovered that it was this vitamin "D" that gave cod liver oil its valuable properties, they have been trying to incorporate this substance or principle in other foods more tasteful to the palate. By giving it a new home, so to speak, science hopes to make the vitamin "D" as well thought of and as well liked as is any dish of cereal with cream. The problem is to store up this vitamin in foods by artificial means. Only recently has this been accomplished.

It has long been known that the presence of the vitamin D in foods is due to the action of ultra-violet light. In the ocean, for instance, the minute plant life which exists at the surface of the water is subjected constantly to the action of the ultra-violet rays from the sun, thereby storing up in this plant life the vitamin "D." As a consequence, fish which feed on this plant life also store up this vitamin in their bodies in turn making it available to man in the form of cod liver oil and similar animal products. The green vegetables which are so popular these days, the growth of which depends directly on sunlight, also contain this vitamin.

Knowing this action of ultra violet light scientists, for many years have been trying to devise a method whereby the vitamin "D" might be stored up in foods which do not contain it, by subjecting these foods to the action of ultra-violet light. Until quite recently, when Professor Harry Steenbach of the University of Wisconsin developed a method for irradiating cereals, no investigator in this field met with success.

Professor Steenbach's method, however, is quite successful and recently it has been applied on a large commercial scale in one of the mills of the Quaker Oats Co. In this mill on endless belt conveyors, arranged in moving step formation, milled wheat, steamed and sterilized is fed in a thin layer on broad moving belts which pass slowly under the vitalizing glow of quartz mercury vapor lamps. Before moving into the influence of the invisible rays the grain is just like any other grain; a short distance beyond, although it is unchanged in appearance, it contains a supply of the rare vitamin "D" so helpful to the human organism.

What could be simpler? On one side of the belt we have wheat, wholesome enough to be sure but without the calcium assimilating properties we desire. Pass this wheat under the ultra violet lamp and Presto! we have vitalized it with new life-giving properties.

The equipment used is simple, consisting merely of suitably designed Cooper Hewitt mercury vapor lamps energized with electricity furnished by standard General Electric motor generator sets. Behind this simple arrangement, however, lies more than a century of study and research by many eminent scientists.

Food subjected to this irradiating process undergoes absolutely no change in appearance or flavor and it can be used exactly as before. It makes possible, however, the effective use by the body, of the rich calcium content of milk. Instead of using milk to make a better food out of cereals, the irradiated cereal can now be used to make a better food out of milk or cream.

Professor Steenbach has made numerous tests of the commercially irradiated cereals. In one instance groups of dogs, litter mates, were kept in darkness and fed on the same nutrient ration in every respect, except that the cereal fed one group was irradiated while that for another group was not. The dogs eating the unirradiated rations developed pronounced cases of rickets, while the other group grew normally and healthy in every respect.

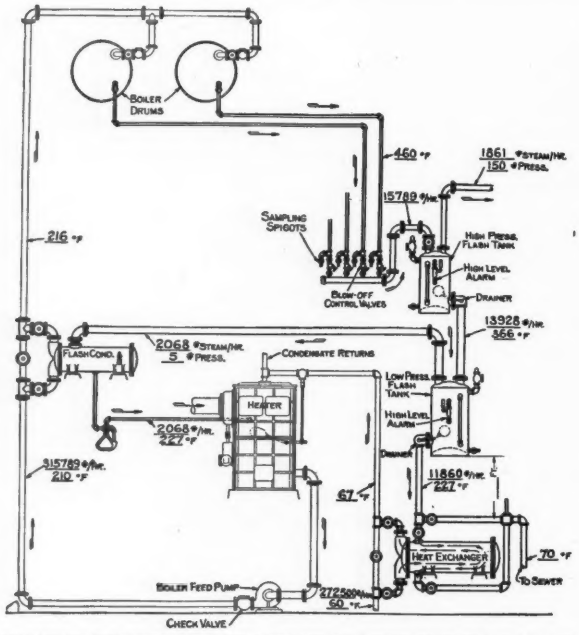
So far, only a few cereals have been irradiated, the first being wheat farina. Muffets, another ready-to-eat cereal, is also being vitalized on a commercial scale. While the irradiation of these foods has been successful it must not be construed that the Quaker Oats Co. is seeking to substitute irradiated cereals for sun light, cod liver oil or fresh vegetables. The new foods are offered simply as another source of an essential diet element.

Power Plant Engineering Developments and News

Continuous Boiler Blowoff Aids Heat Recovery

By J. D. Yoder*

BLOWING OFF boilers to prevent undesirably high condensation of solids in the boiler may waste as much as 5 or 10 per cent of the water fed into the boiler. Continuous blowoff, while valuable, is not a cure for all troubles induced by an unsatisfactory boiler supply.



HEAT IS RECOVERED IN THREE STAGES, INTERMEDIATE, LOW AND ATMOSPHERIC PRESSURES

Water which naturally causes scaling or corrosion will do so even though a continuous blowoff equipment is installed but concentration of sodium salts within the boiler can be controlled by blowing down and continuous blowoff equipment permits recovering the heat of the liquid.

It is important that blowing down be simply and easily accomplished, with facilities for readily determining the concentration in the boiler. As the orifice for continuous blow-down is necessarily small, the automatic blowdown cannot be depended upon for the removal of large particles of scale and the regular blow-down should also be provided. Taking the continuous blowoff water from a level only slightly below the low working level within the boiler, at such a position as will remove the most highly concentrated boiler water or that diluted as little as possible by fresh feedwater, prevents accidental lowering of the water level in the boiler sufficiently to burn the tubes, since when the level of the water falls below the level of the blowdown pipe connection, only steam escapes through the comparatively small orifice, which does no harm.

Continuous blowoff equipment shown in the accompanying drawing is especially adapted for high-pressure boiler plants where there is also a demand for steam at a pressure intermediate between that of the exhaust and the boiler pressure.

From the upper drum or furnace tube headers of each boiler, a comparatively small blowoff pipe is run to a location which will be convenient for adjusting the continuous blowoff valves and for drawing samples of blowoff water for testing. Discharge from the several blowoff control valves enters a common manifold which discharges, as illustrated, into a flash tank having suitable baffles on the inside for purifying the flashed steam. For the plant shown the boiler pressure is 450 lb. and the high-pressure flash tank is operated at 150 lb., a steam line of suitable size connecting the top of the flash tank to the 150-lb. pressure main.

If the boiler feedwater contains 10 grains of mineral solids per gallon and a concentration within the boiler of 200 grains per gallon is permissible, this requires that one gallon of concentrated water, containing 200 grains mineral solids, must be removed from the boiler for every 20 gal. delivered, or that the blowoff must be equal to 5 per cent of the water fed. If the rate of steam generation is to be 300,000 lb. per hr., this corresponds to feeding the boilers with 315,789 lb. per hr. At 450 lb. pressure, the temperature of water is 460 deg. and 15,789 lb. of feedwater at this temperature will produce 1861 lb. of steam at 150 lb. pressure and 13,928 lb. of water at 366 deg., which is the temperature for 150 lb. Utilizing the 1861 lb. of steam at the pressure of 150 lb. affords considerable economy as compared with recovering all of the heat at the pressure of the exhaust steam.

From the high-pressure flash tank, the 13,928 lb. of water discharges into a similarly designed low-pressure flash tank at 5 lb. where 2068 lb. per hr. of flashed steam is produced, to be condensed in the flash condenser through which the boiler feedwater is pumped from the open feedwater heater and heated from 210 to 216 deg. F. The condensate from the 2068 lb. of flashed steam is returned to the open feedwater heater through a low-pressure drainer, thence to the boilers. From the

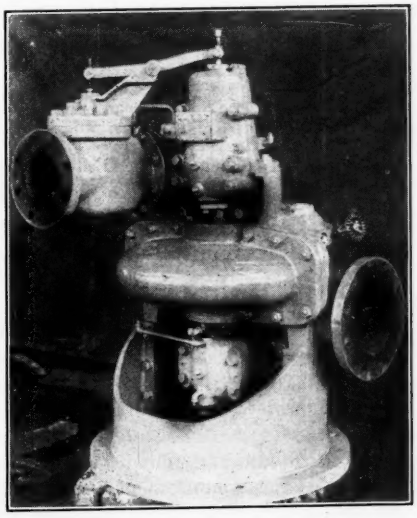
*Cochrane Corporation, Philadelphia, Pa.

low-pressure flash condenser, 11,860 lb. per hr. of water at a temperature of 227 deg. F. is passed through a heat exchanger, then to the sewer at a temperature of 70 deg. The make-up water also passes through the heat exchanger and is heated from 60 deg. to 67 deg. before being admitted to the open feedwater heater. If desired, steam from the low-pressure flash tank can be delivered into the open feedwater heater, thus simplifying the equipment by the omission of the flash tank and low-pressure drainer.

Steam Turbines for Driving Vertical Shaft Equipment

TWO FORMS of vertical steam turbines, for driving deepwell pumps, vertical fans, pulverizers and other equipment with vertical shafts, have recently been added to its line of turbines by Murray Iron Works Co., Burlington, Iowa.

These turbines are equipped with constant-speed and emergency governors operating independent valves and may also be equipped with constant-pressure governors.



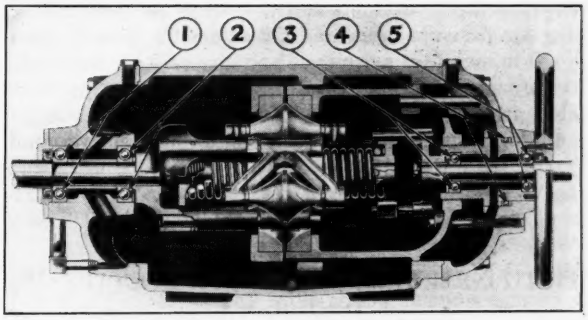
VERTICAL TURBINE FOR DIRECT CONNECTION TO VERTICAL-SHAFT AUXILIARIES

Blading and nozzles are of the standard, non-corrosive, non-erosive Murray type; packing is carbon, steam sealed. All discs are forgings with two revolving rows of blading on each wheel.

These turbines are equipped with extra nozzles for overloads or decreased steam pressure and are arranged for manual or automatic operation as required.

JFS Speed Changer Has Ball Bearings

INCORPORATION of high-grade ball bearing mountings throughout the entire JFS variable reducer transmission is announced by The Stephens-Adamson Mfg. Co., Aurora, Ill. All sizes and types have been equipped with five ball bearings in each frame at vital points. The new arrangement is intended to provide a new degree of smooth operation and to assure the lubrication of every running part. Every ball bearing is accurately set and adequately lubricated. The internal circulation of the oil bath is accomplished by the actual splashing of the revolving parts. Two ball bearings support the high speed shaft and two support the variable speed shaft. The oil drain in each bearing cavity is arranged at sufficient height to insure a constant supply of lubricant at all times.

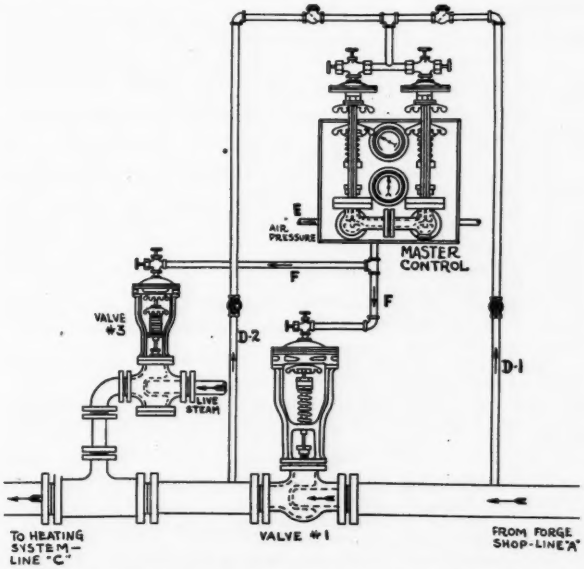


SECTION THROUGH SPEED CHANGER SHOWING WHERE BALL BEARINGS ARE USED

Master Control Guards Against Pressure Drop

FROM THE LARGE forge shops of the Studebaker Corp. lead several miles of underground exhaust lines, supplying steam to the heating system of the entire plant. As a safeguard against pressure drop on this large system, where an absolutely constant pressure was required, A. B. Edgell has adopted the Swartwout master control, controlling a group of Swartwout valves, as shown in the sketch.

During working hours of the forge shop, 10-lb. pressure is maintained on line C through a 12-in. valve in line A. After working hours, a pressure drop occurs in line A, allowing pressure to drop to 5 lb. when doing so. Pressure also drops in pilot lines D-1 and D-2,



WHEN PRESSURE DROPS IN LINE A, MASTER CONTROL CLOSES THIS LINE AND ADMITS LIVE STEAM THROUGH VALVE NO. 3

allowing the Swartwout master control to open, admitting air pressure from line E to lines F, opening valve No. 3 to maintain a constant pressure of 5 lb. on line C, at the same time forcing valve No. 1 to a closed position. This, it is stated, eliminates the unnecessary cost of supplying steam to the many miles of underground piping back through line A. This master control and the valves No. 1 and No. 3 are products of The Swartwout Co., 18511 Euclid Ave., Cleveland, Ohio.

Third National Fuels Meeting Oct. 7-10, at Philadelphia

ADVANCE PROGRAM of the Third National Fuels Meeting, which will be held in Philadelphia, Pa., October 7 to 10, 1929, is given below, as announced by the A. S. M. E. Advance copies of many of the papers will be available prior to the meeting for those who wish to enter the discussions.

This meeting is to be held under the auspices of the Philadelphia section, American Society of Mechanical Engineers and its headquarters will be at the Bellevue-Stratford Hotel. Victor J. Azbe, consulting engineer, 6625 Delmar Blvd., St. Louis, Mo., is chairman, executive committee of Fuels Division, A.S.M.E., and H. A. Hoffer, eastern sales manager, U. S. Pipe & Foundry Co., 1421 Chestnut St., Philadelphia, Pa., is chairman of the local general arrangements committee. Further details in regard to meetings and papers can be obtained from these men. The meeting is arranged for all engineers interested in production and use of fuels, regardless of society affiliations, and anyone interested will be permitted to take part in the discussion.

The advance program is as follows:

GENERAL

1. Opening Address: The Fuel Engineer, His Training and Work, Prof. R. H. Fernald, University of Pennsylvania, Philadelphia, Pa.
2. Economics of Reclamation of Anthracite Culm, Frederick H. Dechant, Cons. Engr., W. H. Dechant & Sons, Reading, Pa.
3. Cleaning of Anthracite, T. M. Chance, Cons. Mining Engr., H. M. Chance & Co., Philadelphia, Pa.
4. Low-Temperature Carbonization, Max Toltz, St. Paul, Minn.
5. Low-Temperature Carbonization, J. McQuade, Ben. Franklin Coal Co. of West Virginia, Moundsville, W. Va.
6. Economics of Coal, Gas and Oil Fuels, Martin Frisch, Engr. Charge of Development, Combustion Engrg. Corp., New York, N. Y.
7. Coal Pretreatment, Clarence B. Wisner, President, Carbocite Co., Canton, Ohio.

POWER PLANT

8. Water-Cooled Furnace Walls, Ollison Craig, Cons. Engr., Riley Stoker Corp., Worcester, Mass.
9. Water-Cooled Furnace Walls, J. S. Bennett, Engr., and P. N. Oberholtzer, Engrg. Dept. American Engrg. Co., Philadelphia, Pa.
10. Sampling Pulverized Fuel, H. C. Porter, Cons. Chemical Engr., Philadelphia, Pa.
11. Symposium on Recent Developments in Mechanical Stoker Design: Presentation by H. D. Savage, President, Stoker Manufacturers Assn., New York, N. Y.

Co-Authors: R. A. Foresman, Chief Engr., Stoker Dept. Westinghouse Electric & Mfg. Co., Philadelphia, Pa.; J. G. Worker, Gen. Sales Mgr., American Engrg. Co., Philadelphia, Pa.; J. W. Armour Engrg. Mgr., Riley Stoker Corp., Worcester, Mass.

INDUSTRIAL

12. Fuel Burning in Ceramic and Lime Industries, Victor J. Azbe, Cons. Engr., St. Louis, Mo.
13. Economics of Industrial Heating, J. A. Doyle, Vice-Pres., W. S. Rockwell Co., New York, N. Y.
14. Electricity for Industrial Heating Furnaces, W. S. Scott, Westinghouse Electric & Mfg. Co., Mansfield, Ohio.
15. Gas for Industrial Heating Furnaces, H. O. Loebell, Chief Engr., Combustion Utilities Corp., New York, N. Y.
16. Oil for Industrial Heating Furnaces, Leo D. Becker, Editor, Fuel Oil Magazine, New York, N. Y.
17. Philfuels, R. W. Thomas, Vice-Pres., Philfuels Co., Bartlesville, Okla.

DOMESTIC

18. Symposium on Domestic Heating. Papers on:

Economics of House Heating and Insulation, H. B. Johns, People Gas, Light & Coke Co., Chicago, Ill.

Gas, M. J. Roberts, Pres., Roberts Gordon Appliance Co., Buffalo, N. Y.

Oil, H. F. Tapp, Technologist and Assistant Secretary, American Oil Burner Assn., New York, N. Y.

Electricity, A. R. Stevenson, Jr., Engr., Gen'l Dept. General Electric Co., Schenectady, N. Y.

Anthracite, A. F. Duemler, Mgr., Anthracite Coal Service, New York, N. Y.

Bituminous, F. R. Wadleigh, Cons. Engr., New York, N. Y.

Coke, P. Nicholls, U. S. Bureau of Mines, Pittsburgh, Pa.

19. Some Fundamentals of the Domestic Heating Problem, Samuel S. Wyer, Cons. Engr., Columbus, Ohio.
20. Stokers for Apartment Houses and Office Buildings, Joseph Harrington, Pres., Joseph Harrington Co., Riverside, Ill.

SMOKE ABATEMENT

21. Smoke Abatement at Salt Lake City, J. Billeter, Chief Smoke Inspector, Salt Lake City, Utah.
22. Smoke Abatement at Nashville, Tennessee, George C. Fisher, Chief Smoke Inspector, Nashville, Tenn.
23. Smoke Abatement at Knoxville, Tennessee, F. L. Wilkinson, Jr., Chief Engineer, Bureau of Smoke Regulation, Knoxville, Tenn.
24. Effect of Pulverized Fuel Ash on Penetration of Ultra-Violet Rays, Philip Drinker, Asst. Professor of Ventilation and Illumination and Dept. of Physics, Harvard University, Cambridge, Mass.
25. Smoke Abatement, Harvey N. Davis, Pres., Stevens Institute of Technology, Hoboken, N. J.
26. Symposium on Methods of Recording Smoke Density, Papers by: A. S. Langsdorf, Acting Dean, Schools of Engrg. and Arch., Washington University, St. Louis, Mo.; H. V. Breisky, Supply Engrg. Dept., Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., and U. P. Griffin, Mech. Operating Engr., Duquesne Light Co., Pittsburgh, Pa.; Victor J. Azbe, Cons. Engr., St. Louis, Mo.

National Electrical Exposition to Be Held Oct. 7-12

NATIONAL ELECTRICAL EXPOSITION to be held in Grand Central Palace, New York City, Oct. 7 to 12, has already signed 90 manufacturers of electrical equipment and is attracting wide attention from the industrial user and the domestic consumer of electrical current, according to a recent announcement.

Nothing but electrical equipment will be featured. This announcement of policy comes from the Electrical Board of Trade of New York and the New York Electrical League, sponsors of the exposition, and the International Exposition Co., managing directors of the show.

Separate hours will be reserved for industrial and trade visitors and the general public. From 10 a. m. until 2 p. m., admission will be restricted exclusively to the trade, to industrial and commercial users. Children will not be admitted at any hour. The general public will be welcomed from 2 p. m. until closing time.

Included in the diversified field of exhibitors who have already reserved space are: schedule or installation material, lighting fixtures, radio equipment, mechanical tools, therapeutic equipment, time pieces, household utilities, service organizations, contractors supplies, utility appliances and precision instruments.

Daily programs have been planned along industrial, commercial and educational lines. Among these may be mentioned the history and development of the radio and a practical demonstration of the methods employed in the making of a talking movie.

Light's Golden Jubilee, in celebration of the 50 golden years of lighting and electrical progress and the golden anniversary of Thomas A. Edison's invention of the first practical incandescent lamp, will also have its place in the exposition by focusing the attention of the entire world on lighting and the electrical industry.

The men in charge of the exposition are: Theodore H. Joseph, chairman, E-J Electric Installation Co.; S. E. Kimball, Kimball Electric Co.; W. B. DeForest, Graybar Electric Co.; Harry A. Hanft, electrical contractor; W. B. Pierce, Edison Electric Appliance Co.; Hugo Tollner, Tollner Electric Co.; W. S. McClure, New York Edison Co., and Earl Whitehorne, president of the Electrical Board of Trade of New York and the New York Electrical League. Fred W. Payne and Charles F. Roth are co-managers of the exposition.

Great Lakes Division, N.E.L.A. to Meet at French Lick Sept. 26-28

NINTH ANNUAL CONVENTION, Great Lakes Division, National Electric Light Association, will be held September 26-28 at French Lick Springs Hotel, French Lick, Ind. Among those who have accepted invitations to be on the program, according to a recent announcement, are M. S. Sloan, president, N.E.L.A., and president, New York Edison Co.; C. F. Hirschfield, director of research, Detroit Edison Co.; A. D. Bailey, chairman, Engineering National Section, N.E.L.A.; Marshall E. Sampsell, president, Central Illinois Public Co. and chairman, Commercial National Section; G. C. Neff, president, Great Lakes Division.

Subjects on the program will cover customer contacts, research, public policy, industrial and agricultural problems, rates, competition, regulations, lighting and so on. Arrangements have been made with the Electric Research Products Co. for presentation of sound pictures covering the Atlantic City Convention.

On Wednesday night, Sept. 25, a special train will run direct from Chicago to French Lick and reservations and full information about this train can be obtained from Ross I. Parker, chairman, transportation committee, General Electric Co., 230 So. Clark St., Chicago, Ill. Hotel reservations should be made direct with the French Lick Springs Hotel Co., French Lick, Ind. Further details may be obtained from G. C. Neff, president, or Tom C. Polk, secretary, Great Lakes Division, N.E.L.A., Room 910, 140 So. Dearborn St., Chicago.

City of San Francisco to Take Over Utility Properties

ACCORDING TO a recent announcement, the Railroad Commission of the State of California has issued decisions fixing the price to be paid by the City and County of San Francisco for the electric systems of Great Western Power Co. and Pacific Gas and Electric Co. within the city, as they existed on February 11, 1924, at $11,815,000 and $26,685,000 respectively. These decisions bring to a close proceedings filed before the Railroad Commission by the City of San Francisco on February 11, 1924, which, taken together, are thought to be the largest case of the kind ever tried in the country.

Property of both companies consists of steam generating and sub-stations and complete overhead and underground system for distribution. Property of the Pacific Gas & Electric Co. includes a steam electric generating plant of 85,000 hp. capacity, 9 substations and over 3500 mi. of line and cable. Property of the Great Western Power Co. includes two steam plants with a total of 30,000 hp. capacity, 4 sub-stations, and over 800 mi. of line and cable.

The Commission based its findings on an inventory and appraisal of the physical property with an additional allowance for the value of the business connected thereto.

During the trial of these proceedings, many extensions and improvements have been made by the companies to their properties; thus, when they are finally taken over by the city, another investigation must be made by the Commission to determine the increase in the value of the property by reason of these improvements.

Death of Luther B. McMillan

LUTHER B. MCMILLAN, for 13 yr. general consulting engineer of the Johns-Manville Corp., died Saturday, August 10, from injuries received in an airplane accident near the airport at Newark, N. J.

Mr. McMillan was born at Bem, Missouri, September 1, 1891. He was graduated from the Texas Agricultural and Mechanical College in 1911 with the degree of Bachelor of Science in mechanical engineering. He later took graduate work in mechanical engineering and chemical engineering at this institution and was instructor in mechanical engineering in 1912 and 1913. He received the degree of Mechanical Engineer in 1912 and of Chemical Engineer in 1913.

He was awarded a fellowship in engineering at the College of Engineering at University of Wisconsin for 1913-14 and received the degree of Master of Science in 1914. After serving two years as instructor in steam and gas engineering at this institution and specializing in research pertaining to the science of heat transmisson, with particular attention to heat transfer through insulation, he became general consulting engineer for the Johns-Manville Corp.

Mr. McMillan was a member of the American Society of Mechanical Engineers, American Society of Heating and Ventilating Engineers, the American Society of Refrigerating Engineers and the Society of American Military Engineers, and belonged to the Engineers' Club, Western Universities Club and the Texas Agricultural and Mechanical College Club of New York.

Always a very active member of the American Society of Mechanical Engineers, he served on many important committees and was a member of the council at the time of his death.

He was frequently called upon to read papers before engineering societies. He also contributed many articles on various phases of insulation to the technical press and prepared technical data for Kent's and Marks' Handbooks, the American Society of Heating and Ventilating Engineers' Guide, the Handbook of the National District Heating Association and similar publications. Due to his standing in his profession, he was prominently identified with the National Research Council.

James T. Hutchings Dies

JAMES T. HUTCHINGS, vice-president of the United Gas Improvement Co. in charge of engineering development, died suddenly on Saturday, August 17, at Ocean City, N. J. Heart disease was the cause. Mr. Hutchings had returned on August 13 from a two months' trip abroad.

Mr. Hutchings entered the employ of the U. G. I. Co. in 1920, as assistant general manager. In August, 1921, he became general manager and two years later

JAMES T. HUTCHINGS

was elected vice-president in charge of operations. In February, 1927, he became vice-president in charge of engineering development.

Born in Amherst, Mass., in 1869, he was graduated from Massachusetts Agricultural College with the degree of bachelor of science in 1889. His first position after graduating was with the Thomson-Houston Electric Co. of Amherst. From 1897 to 1904, he was employed by the Philadelphia Electric Co. as assistant electrical engineer.

Then followed 16 yr. with the Rochester Gas and Electric Corp. during which he held the positions of superintendent of the electric department, assistant manager, general manager and president. He capably filled the latter position for two years, until 1920, when he entered U. G. I. employ.

During the World War, Mr. Hutchings was chairman of the Manufacturers' Committee of the Rochester District, in charge of production, and despite the exigencies of that and his regular work, was also power expert for the Ordnance Department in charge of munitions production. He was a member of the American Gas Association, National Electrical Light Association, American Institute of Electrical Engineer, Engineers' Clubs of Philadelphia and New York.

WHEN DESIGNING a plant, space should always be provided around equipment for making repairs. Often repair or replacement conditions are much less favorable than when the installation is originally made.

Piping and valves should receive particular attention and a working space should always be provided around flanges. One of the most common practices of young draftsmen laying out piping is to put the valves in inaccessible places and dangerous locations losing sight of the fact that the operating men must reach them often or that valve stems projecting into passageways are a grave source of danger.

News Notes

ACCORDING TO A RECENT ANNOUNCEMENT, plans are well under way for the eighth National Exposition of Power and Mechanical Engineering at Grand Central Palace, New York City, opening December 2 and continuing throughout the week. In 1922 the attendance at the show was only 47,589. Last year's attendance had risen to 123,000 and the number of exhibitors had made the phenomenal showing of 542 in 1928 as against only 105 in the first year of the exposition.

This growth, it is pointed out, is due largely to the fact that the exposition covers the entire field of power generation and mechanical engineering. It represents a nation-wide gathering of exhibitors, carrying a complete collection of machinery and products intimately related to the subject.

Another important factor entering into the remarkable growth of the show can be traced to new developments in the field. Never in the history of science has there been such rapid and exceptional advancement in mechanical engineering equipment as during the years the exposition has been functioning.

From a list of over 400 corporations which have already reserved space, this year's exhibits may well be grouped into three general classes: first, new developments, comprising new inventions, new processes and new ideas; second, improvements on old principles and third, those grouped under engineering staples.

Coincident with the National Power Show, the American Society of Mechanical Engineers will hold its annual meeting in New York City.

The advisory committee of the National Power Show is made up of the following engineers: I. E. Moultrop, chairman, Edison Electric Illuminating Co., Boston; Homer Addams, past president, A. S. H. & V.; A. Black, chairman, professional divisions, A. S. M. E.; N. A. Carle, general manager, Pacific Electric & Manufacturing Co.; Fred Felderman, past national president, N. A. P. E.; F. M. Gibson, chairman, power division, A. S. M. E.; C. F. Hirshfeld, chief of research department, Detroit Edison Co.; O. P. Hood, chief mechanical engineer, United States Bureau of Mines; John H. Lawrence, Thomas E. Murray, Inc.; Thornton Lewis, president, A. S. H. & V. E.; Fred R. Low, past president, A. S. M. E.; David Moffatt Myers, consulting engineer; M. S. Sloan, president, N. E. L. A.; Arthur J. Wood, president, A. S. R. E. Fred W. Payne and Charles F. Roth, with offices in Grand Central Palace, New York, will manage the National Power Show.

APPOINTMENT of a communications committee to study proposed legislation involving wire and wireless control is announced by the American Engineering Council. The chairman is Edwin F. Wendt of Washington, D. C. Other members are: O. H. Caldwell, New York, Federal Radio Commissioner; Dean Dexter S. Kimball, Cornell University; Frank A. Scott, Cleveland; Charles B. Hawley, Washington, D. C.

COMBUSTION ENGINEERING CORPORATION announces the discontinuance of its representation in New England by Schumaker-Santry Co. of Boston, and has established a Boston district office at 1000 Arlington St., with J. J. Brady as district manager, M. E. Yeager, sales engineer and S. J. Harris, representative. F. L. Farrell and D. F. Jones, under the firm name Farrell & Jones, have taken over accounts formerly handled by the Schumaker-Santry Co. and will be located at 10 High St., Boston.

M. SHEFFLER AND SAMUEL GROSS of the Sheffler-Gross Co., Inc., Sales Engineers, Philadelphia, have purchased a substantial interest in the newly organized Delaware County Central Heating Co. This company will operate the plant formerly owned by the Springfield Heat Co., located at Springfield, Delaware County, Pa.

GRAVER CORP., East Chicago, Ind., has appointed William E. Dunbar as southeastern sales engineer, located at Florida Theater Building, Jacksonville, Fla. His territory will include the states of Florida, Georgia and Alabama.

AT A MEETING of the Directors of Thomas E. Murray, Inc., on August 14, John H. Lawrence, vice-president and manager of the company since its organization, was elected president. After his graduation from Cornell University, Mr. Lawrence was employed in the engineering department of the New York Edison Co. In 1919, the late Thomas E. Murray, in order to consolidate the various consulting engineering activities he had engaged in for many years, formed the company which bears his name and selected Mr. Lawrence as active head in charge. Mr. Lawrence has been recognized as an authority on power plant design and as having contributed largely to the advance in power plant design which has been made in recent years and which has resulted so materially in reducing the cost of power production. He is the holder of many patents covering improvements in power plants. He has presented many papers before the engineering societies, dealing chiefly with

various phases of power plant design and construction and has been a lecturer in the Engineering School at Cornell University. Mr. Lawrence is a member of the Engineers Club of New York, member of the American Institute of Science and the Power Generation Committee of the American Institute of Electrical Engineers. He has been chairman of the Professional Divisions and chairman of the Metropolitan Section of the American Society of Mechanical Engineers. He is at present vice-president of that society and a member of its executive committee. He has recently been nominated as delegate to the American Engineering Council. Thomas E. Murray, Jr., is chairman of the board of the company, and Joseph B. Murray and John F. Murray are vice-presidents.

E. J. SCHWANHAUSSER, for the past two years assistant manager of the Harrison works of the Worthington Pump and Machinery Corp., has been appointed manager of that company's Buffalo works. Only 35 yr. of age, Mr. Schwanhausser is one of the youngest executives in the Worthington organization whose employ he entered while yet a student at Stevens Institute of Technology. During the summers of 1912, 1913 and 1914 he was employed in the various shops and on the testing floors at Harrison. Immediately upon his graduation in 1915, Mr. Schwanhausser was made test and erection engineer. In 1917, he was transferred to the condenser engineering department and in 1919, he was made machine shop equipment engineer. In 1920, Mr. Schwanhausser was promoted to the superintendency of the machine shops; in 1923, he was appointed superintendent of the field erection department. He became engineering assistant to the manager in 1926, was made assistant to the manager in 1927 and, a few months later, was appointed assistant works manager.

THE CENTRAL ARIZONA LIGHT & POWER Co., Phoenix, Ariz., an interest of the Electric Bond & Share Co., New York, has approved final plans for the construction of a new steam-operated electric generating plant at a place known as Lateral 16, near the line of the Southern Pacific Railway. The plant will be of modern construction throughout and is estimated to cost about $2,500,000, including transmission lines for connection with present system, for service at Phoenix and other centers. The units will be of steel and concrete type, with 250 ft. concrete stack; an office building will also be erected at the power site. The construction will be carried out by the Phoenix Utility Co., an affiliated organization, with F. S. Bird, superintendent of construction.

THE CITY ICE & FUEL Co., Cleveland, Ohio, which has expanded its holdings considerably in recent months, has concluded negotiations for the purchase of the plants and business of the Bison Ice & Coal Co., and the Gould Ice Co., Inc., Buffalo, N. Y., and will operate in conjunction with its other properties in that city. It is understood that the company will make extensions and betterments in the purchased plants for increased output. This will make a total of eight ice-manufacturing and cold storage plants in the Buffalo district. Since the first of the year, the City Ice & Fuel Co. has acquired seven plants at Pittsburgh, Pa.; three plants at Dayton, Ohio; one at Painesville, Ohio; and one in Marion, Ohio. In addition, that same period, ice-manufacturing plants have been built at Toledo and Willoughby, Ohio; at Troy, N. Y.; and at Oakwood and Port Huron, Mich.; and extensions carried out at plants at New York, N. Y., and Cincinnati, Ohio, doubling former outputs. The company is now operating a total of 115 ice-manufacturing plants in 21 States and in Canada, with gross capacity of 19,370 t. per day. It is expected to break ground for a new car-icing plant at Fort Worth, Texas, at an early date, reported to cost upward of $50,000.

CARL A. DUFFNER, president of Domestic Electric Co., Cleveland, Ohio, announces that it has just purchased a group of buildings and a tract of land at Kent, Ohio, to be devoted solely to the manufacture of fractional horsepower motors of the universal type, for every conceivable type of motor-driven device on the market. The Domestic Electric Co. is a division of Black & Decker, Towson, Maryland.

EQUIPMENT for a new steam generating unit for the municipal plant at Springfield, Ill., was purchased in August. This consists of a 7596 sq. ft. Babcock & Wilcox boiler with a 1675-sq. ft. economizer and a 5655-ft. tubular air heater and has a maximum steam capacity of 90,000 lb. per hr. It is built for 400 lb. pressure and 250 deg. F. superheat but will be operated initially at 200 lb. and 125 deg. F. superheat. The boiler will be fired by Babcock & Wilcox chain grate stoker; the furnace will be cooled on all four walls with a total of 573 sq. ft. of Bailey water-cooled wall.

Chain grate stokers were selected solely to eliminate changes in the present ash handling system of the plant as all ash is now pumped to a slough using 5-in. ash pumps which are too small to dispose of the ash coming coming from the clinker grinder of an underfeed stoker.

Burns & McDonnell Engineering Co. of Kansas City were consulting engineers.

Catalog Notes

THE VENTURAFIN METHOD of Heating is discussed in an attractive 24-page, Bulletin 7818, just issued by American Blower Corp., Detroit, Mich. Details of construction of the Venturafin heater and methods of application are shown with dimension, weight and capacity tables. Sirocco Forced Draft Fans for Domestic Heating Plants are described in detail in Bulletin No. 10401, also issued recently by this company.

ALUMINUM ENTERS THE VENTILATING FIELD, a recent bulletin issued by the Burt Mfg. Co., Akron, Ohio, describes its ventilators made of this metal to resist corrosion where acid fumes or other corrosive gases are to be handled.

DIESEL ENGINES AND THEIR LUBRICATION is the subject of Engineering Bulletin D-29, just issued by Technical Division, Standard Oil Co., (Ind.), Chicago, Ill. Principles of the Diesel engine are first discussed in detail, followed by data on operation, maintenance and fuel. Details of lubrication of various parts are given by text, illustrations and line drawings.

LEAFLET 20,355-A has been issued by the Westinghouse Electric & Manufacturing Co., covering Type ES engine-driven alternating-current synchronous generators. These generators are designed for direct connection to steam, gas or oil engines and are built completely of structural steel, fabricated with the electric arc.

CONNELLY BOILERS are described and illustrated in an attractive 58-page bulletin just published by the D. Connelly Boiler Co., Ivanhoe Road, Cleveland, Ohio. After discussing the history of the company, the bulletin presents data on its facilities and discusses in detail the fundamentals of design of its boilers. Details of drums and tubes are shown, both in course of manufacture and erected, while line drawings, photographs and text show many actual installations of these units in all types of plants. Data on performance are given, with steam tables, pipe and chimney data and other engineering information.

HYDRAULIC TURBINES and auxiliaries are described and illustrated in Bulletin 1644 recently issued by Allis-Chalmers Mfg. Co., Milwaukee, Wis. Its 76 well-illustrated pages show by line drawings and photographs many large installations of hydraulic turbines made by this company. Views of various runners and turbine parts are shown, for reaction, impulse and propeller type units. The final pages discuss governors, pressure regulators and large butterfly valves.

CONTINUOUS BLOW-OFF EQUIPMENT and the heat and condensate saving by its use are described and illustrated in Cochrane Bulletin No. 683 issued by The Cochrane Corp., 3144 No. 17th St., Philadelphia, Pa.

WESTINGHOUSE ELECTRIC AND MFG. Co. announces the publication and distribution of its leaflet No. 20392, entitled, Cog Belt Drives for Industrial Service. The uses, advantages and construction of cog belt drives are clearly and concisely explained. Illustrations of construction and application of these drives are included. The leaflet also includes a table of available standard sizes of belts.

CHAIN BELT Co., Milwaukee, Wisc., and the Stearns Conveyor Co., a division of the Chain Belt Co., have issued the new Rex 330 Catalog and Engineering Data Book. This book is devoted to chains, power transmission, water screening and mechanical conveying and contains 800 pages filled with valuable information on the subjects covered. The book is well illustrated and discusses the mechanical handling problems in a number of representative industries, among which are the automobile industry, automobile laundries, power plants, cement mills, glass plants, pulp mills, sewage disposal plants, tire and rubber plants and canning plants.

THE GENERAL STOKER CORP., 270 Lafayette St., New York, N. Y., has recently issued a folder describing the Type E General Stoker for power and heating boilers, ranging in capacities from 75 to 125 hp. The folder illustrates details of the stoker and installation views, as well as a cross section of typical installations under a return tubular boiler.

UNDER THE TITLE "Foxboro Instruments in the Power Plant," the Foxboro Co., Foxboro, Mass., has issued its bulletin No. 115-2. This is a 28-page book, printed in color, illustrating and describing the various instruments manufactured by the Foxboro Co., which are of use in the power plant. Not only are the instruments described but their uses are pointed out and their proper locations in the power plant indicated on a cross section of a typical plant.

WAGNER ELECTRIC CORP., St. Louis, Mo., has issued its bulletin No. 159 covering all types of vertical motors in ratings from 1½ to 30 hp. The unique feature of these motors is that they all have the same flange or lug dimensions, making it possible for manufacturers and users of small motor-driven machinery to interchange motors of different types and ratings on the same mounting dimension.

Power Plant Construction News

Ala., Birmingham—The Birmingham Gas Co. is said to have preliminary plans under way for extensions and improvements in plant and system, reported to cost more than $400,000.

Ark., Russelville—The City Council has approved plans for the construction of a municipal electric light and power plant, with distributing system, entire project to cost about $240,000. W. L. Winters, Merchants Bank Building, Fort Smith, Ark., is engineer.

Calif., Long Beach—The Consolidated Aircraft Corporation, Elmwood Avenue, Buffalo, N. Y., plans installation of power equipment in connection with projected aircraft manufacturing plant, on 30-acre tract of land recently acquired at Long Beach, entire project reported to cost more than $300,000.

Calif., Yorba Linda—The Yorba Linda Citrus Association plans installation of power equipment in proposed new packing plant, entire project reported to cost close to $100,000.

Conn., Bristol—The New Departure Mfg. Co. has filed plans for construction of one-story and basement power plant, 55x126 ft., at local ball bearing manufacturing plant, reported to cost more than $80,000, with equipment.

Fla., Sarasota—The Sarasota Terminal Docks, Inc., care of T. W. Bryden, Goldenrod Avenue, Sarasota, recently organized by Mr. Bryden and associates, is projecting plans for a cold storage and refrigerating plant in the harbor district, to cost more than $250,000, with equipment.

Ga., Guyton—The Coastal Public Service Co., plans extensions and improvements in electric light and power plant, including the installation of a crude oil engine-generating unit and auxiliary equipment, to increase capacity about 75 kw.

Ill., Chicago—The Temple Corporation, 1925 South Western Avenue, will install power equipment in proposed radio manufacturing plant at LaVergne and West Sixty-fifth Streets, entire project to cost more than $400,000. Foltz & Co., 510 North Dearborn Street, are architects.

Ill., Chicago—The Continental Can Co., 1 Pershing Square, New York, plans installation of power equipment in connection with additions to plant in the Clearing Industrial District, Chicago, reported to cost more than $750,000.

Ill., Peru—The Western Clock Co., Peru, plans installation of power equipment in proposed new addition to plant, entire project to cost about $200,000. A. S. Goodenough is company engineer.

Ind., Fort Wayne—The Dudlo Mfg. Co., Wall Street, has plans nearing completion for a one-story power house for central boiler room service, reported to cost more than $30,000, with equipment. Guy Mahurin, Standard Building, is architect.

Ind., Rosston—The Mount Forrest Fur Farms of America, Inc., Rosston, plans installation of a refrigating plant at local properties, reported to cost more than $35,000, with equipment.

La., Belle Chasse—The Big Chief Oil Refining Co., Godchaux Building, New Orleans, will install power equipment in proposed new oil refining plant at Belle Chasse, near New Orleans, entire project reported to cost more than $500,000.

Md., Baltimore—The Consolidated Gas, Electric Light & Power Co., Lexington Building, has plans for a seven-story equipment storage and distributing plant on South Eutaw Street, reported to cost more than $160,000, with equipment.

Md., Baltimore—The Western Electric Co., 195 Broadway, New York, is said to have plans for the construction of a boiler plant at new works at Riverview Park, Baltimore, now in course of erection, estimated to cost close to $175,000. Entire project to cost more than $2,000,000. The H. K. Ferguson Co., Hanna Building, Cleveland, Ohio, is architect and engineer.

Mich., Detroit—The Detroit Steel Products Co., East Grand Boulevard, will install power equipment in new automobile spring manufacturing plant, project estimated to cost close to $1,000,000.

Mich., Jackson—The Consumers Power Co., Jackson, has plans for the construction of addition to ice plant on Hupp Avenue, estimated to cost about $50,000, with equipment.

Mich., Muskegon—The Henry H. Cross Co., 122 South Michigan Avenue, Chicago, Ill., refined oils, plans installation of power equipment in proposed oil refinery at Muskegon, entire project to cost close to $150,000.

Nebr., Falls City—The Kansas City Gas Service Co., 908 Grand Street, Kansas City, Mo., is said to be planning the construction of new artificial gas plant at Falls City, to cost approximately $45,000, with equipment.

N. J., Bound Brook—The Bakelite Corporation, 247 Park Avenue, plans installation of power equipment in connection with proposed new composition goods manufacturing plant at Bound Brook, entire project reported to cost more than $125,000.

N. D., Lakota—The City Council has approved plans for the construction of a municipal electric light and power plant to cost about $30,000, in which amount bonds recently were voted, and will soon begin superstructure..

N. J., Newark—The American Can Co., 230 Park Avenue, New York, has approved plans for construction of a boiler plant in connection with a general expansion and betterment program in factory on Elizabeth Avenue, Newark, entire project to cost $150,000. Company engineering department is in charge.

N. Y., Brooklyn—The Prudential Ice & Coal Corporation, care of C. P. Cannella, 1163 Herkimer Street, has had revised plans prepared for the construction of one-story ice-manufacturing plant on Willoughby Avenue, reported to cost about $120,000, with equipment.

N. Y., Tupper Lake—The C. H. Elliott & Son Lumber Co. plans rebuilding of engine and boiler house, recently damaged by fire, with installation of equipment. An official estimate of loss has not been announced.

N. Y., Yorkshire—The Niagara, Lockport & Ontario Power Co., Marine Trust Building, Buffalo, N. Y., is reported planning a new steam-operated electric power plant at Yorkshire, to cost in excess of $150,000.

N. C., Asheville—The Home Service Co., 3 Page Avenue, D. D. Smith, president, has made application for a franchise for the construction and operation of a steam power plant for central heating service in the business district, entire project to cost close to $1,000,000.

Ohio, Bolivar—The Timken Roller Bearing Co., Canton, Ohio, is said to be planning the construction of a power house at its plant at Bolivar, reported to cost more than $40,000, with equipment.

Ohio, Canton—The Canton Drop Forge & Mfg. Co., plans installation of power equipment in connection with new plant addition, entire project to cost close to $100,000.

Ohio, North Canton—The Hoover Co., North Canton, plans installation of power equipment in a new four-story addition to electric appliance plant, entire project to cost close to $115,000. L. Christman and C. Firestone, 999 Renkert Building, Canton, Ohio, are architects.

Pa., Beaver Falls—The Standard Steel Specialty Co., plans installation of power equipment in proposed addition to plant in the West Mayfield district, project reported to cost close to $80,000.

Pa., Williamsport—Lycoming Mfg. Co., Williamsport, plans installation of power equipment in proposed addition to automobile engine manufacturing plant, entire project to cost about $100,000. The Austin Co., 1015 Chestnut Street, Philadelphia, is engineer.

Texas, Aransas Pass—The Humble Oil & Refining Co., Houston, has approved plans for a steam-operated electric power plant at its Ingleside oil refinery, vicinity of Aransas Pass, for plant service, reported to cost upward of $100,000.

Texas, Dallas—The Simms Oil Co., Dallas, plans installation of power equipment in proposed extensions and improvements in oil refinery at West Dallas, entire project to cost about $250,000.

Wis., Milwaukee—The Economy Paper Products Co., 1148-52 Hotton Street, plans installation of power equipment in connection with proposed rebuilding of portion of waxed paper manufacturing plant, recently destroyed by fire with loss reported at close to $80,000.

Wis., Milwaukee—The Outboard Motors Corporation, Twenty-seventh Street and Capitol Drive, plans installation of power equipment in new one and two-story addition to marine motor plant, project reported to cost $85,000.